1989

Discrete Semiconductor Products Databook

National Semiconductor

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400047

Discrete Semiconductor Products

Databook

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A Corporate Dedication to Quality and Reliability

National Semiconductor is an industry leader in the manufacture of high quality, high reliability integrated circuits. We have been the leading proponent of driving down IC defects and extending product lifetimes. From raw material through product design, manufacturing and shipping, our quality and reliability is second to none.

We are proud of our success . . . it sets a standard for others to achieve. Yet, our quest for perfection is ongoing so that you, our customer, can continue to rely on National Semiconductor Corporation to produce high quality products for your design systems.

Charlie Sporck

Charles E. Sporck
President, Chief Executive Officer
National Semiconductor Corporation

Wir fühlen uns zu Qualität und Zuverlässigkeit verpflichtet

National Semiconductor Corporation ist führend bei der Herstellung von integrierten Schaltungen hoher Qualität und hoher Zuverlässigkeit. National Semiconductor war schon immer Vorreiter, wenn es galt, die Zahl von IC Ausfällen zu verringern und die Lebensdauern von Produkten zu verbessern. Vom Rohmaterial über Entwurf und Herstellung bis zur Auslieferung, die Qualität und die Zuverlässigkeit der Produkte von National Semiconductor sind unübertroffen.

Wir sind stolz auf unseren Erfolg, der Standards setzt, die für andere erstrebenswert sind. Auch ihre Ansprüche steigen ständig. Sie als unser Kunde können sich auch weiterhin auf National Semiconductor verlassen.

La Qualité et La Fiabilité:

Une Vocation Commune Chez National Semiconductor Corporation

National Semiconductor Corporation est un des leaders industriels qui fabrique des circuits intégrés d'une très grande qualité et d'une fiabilité exceptionelle. National a été le premier à vouloir faire chuter le nombre de circuits intégrés défectueux et a augmenter la durée de vie des produits. Depuis les matières premières, en passant par la conception du produit sa fabrication et son expédition, partout la qualité et la fiabilité chez National sont sans équivalents.

Nous sommes fiers de notre succès et le standard ainsi défini devrait devenir l'objectif à atteindre par les autres sociétés. Et nous continuons à vouloir faire progresser notre recherche de la perfection; il en résulte que vous, qui êtes notre client, pouvez toujours faire confiance à National Semiconductor Corporation, en produisànt des systèmes d'une très grande qualité standard.

Un Impegno Societario di Qualità e Affidabilità

National Semiconductor Corporation è un'industria al vertice nella costruzione di circuiti integrati di altà qualità ed affidabilità. National è stata il principale promotore per l'abbattimento della difettosità dei circuiti integrati e per l'allungamento della vita dei prodotti. Dal materiale grezzo attraverso tutte le fasi di progettazione, costruzione e spedizione, la qualità e affidabilità National non è seconda a nessuno.

Noi siamo orgogliosi del nostro successo che fissa per gli altri un traguardo da raggiungere. Il nostro desiderio di perfezione è d'altra parte illimitato e pertanto tu, nostro cliente, puoi continuare ad affidarti a National Semiconductor Corporation per la produzione dei tuoi sistemi con elevati livelli di qualità.

Charlie Sporck

Charles E. Sporck
President, Chief Executive Officer
National Semiconductor Corporation

DISCRETE SEMICONDUCTOR PRODUCTS
DATABOOK

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TRADEMARKS

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BTL™
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COMBO™
COMBO I™
COMBO II™
COPS™ microcontrollers
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DIB™
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GNX™
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ISE/08™
ISE/16™
ISE32™
ISOPLANAR™
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KeyScan™
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M^{2}CMOS™
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Nitride Plus™
Nitride Plus Oxide™
NML™
NOBUS™
NSC800™
NSCISE™
NSX-16™
NS-XC-16™
NTERCOM™
NURAM™
OXISS™
P^{2}CMOS™
PC Master™
Perfect Watch™
Pharma✓Chek™
PLAN™
PLANAR™
Polycraft™
POSilink™
POSitalker™
Power + Control™
POWERplanar™
QUAD3000™
QUIKLOOK™
RAT™
RTX16™
SABR™
Script✓Chek™
SCX™
SERIES/800™
Series 900™
Series 3000™
Series 32000®
Shelf✓Chek™
SofChek™
SPIRE™
STAR™
Starlink™
STARPLEX™
SuperChip™
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SYS32™
TapePak®
TDS™
TeleGate™
The National Anthem®
Time✓Chek™
TINA™
TLC™
Trapezoidal™
TRI-CODE™
TRI-POLY™
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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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Introduction to the Discrete Semiconductor Products Data Book

For many years National Semiconductor has been a major supplier of discrete semiconductor devices for the wide ranging consumer, automotive, computer and industrial marketplaces. And now . . . the acquisition of Fairchild by National Semiconductor has heralded in a new era for the NSC Discrete Product Line. The combined product lines have greatly magnified the product depth and have now also made Mil-Aero versions available.

This databook reflects the discrete products that were previously sold by Fairchild along with the NSC bi-polar and JFET transistors. These include:

- Commercial and Mil-Aero versions of small signal diodes
- Commercial and Mil-Aero versions of metal can, small signal bipolar transistors
- The combined Fairchild and NSC lines of general purpose, switching and power transistors in plastic encapsulated packages
- Commercial and Mil-Aero versions of monolithic diode arrays
- Quad transistor arrays
- N-Channel, P-Channel and Dual JFET transistors
- Power MOSFETs and ultrafast rectifiers

Many of the above devices are also available in surface mount packages:

- Leadless glass diodes
- SOT diodes and transistors
- SOIC quad transistor and diode arrays

The selection guides in this databook are designed to provide an easy reference to the many standard parts offered by NSC. If your needs are not satisfied by any of the devices listed, please contact your local NSC Sales Office or the factory for lead form options and for other special selections that are available.

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Discrete Product Line
Alphanumeric List of Available Parts

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Reliability and Quality

RELIABILITY VIS-A-VIS QUALITY

The words "reliability" and "quality" are often used interchangeably, as though they connote identical facets of a product's merit. However, reliability and quality are different, and discrete component users must understand the essential difference between the two concepts in order to properly evaluate the various vendors' programs for product integrity.

The concept of quality gives us information about the population of faulty components among good components, and generally relates to the number of faulty components that arrive at a user's facility. Looked at in another way, quality can instead relate to the number of faulty components that escape detection at the component vendor's facility.

It is the function of a vendor's Quality Control arm to monitor the degree of success of that vendor in reducing the number of faulty components that escape detection. QC does this by testing the outgoing parts on a sampled basis. The Acceptable Quality Level (AQL) determines the stringency of the sampling. As the AQL decreases, it becomes more difficult for bad parts to escape detection, thus the quality of the shipped parts increases.

The concept of reliability, on the other hand, refers to how well a part that is initially good will withstand its environment. Reliability is measured by the percentage of parts that fail in a given period of time.

QUALITY IMPROVEMENT

When purchasing a component or a system, it is expected that each item delivered has been thoroughly tested and will perform according to data sheet or detailed specifications.

Additional programs can be implemented to improve quality. To be effective, a program must not only reduce escapes but must also be tailored specifically to detect and remove the types of residual defects that are predicted by process and line monitor control data. The proper analysis and application of this data is a primary objective at National. With emphasis on "ship-to-stock" programs and the need to measure quality levels in ppm's, National Semiconductor has taken a leadership role in an on-going effort to strive for "zero defects".

In Discretes, the benefits derived as a result of this increased emphasis includes the following:

- Escapes caused by mishandling are reduced significantly.
- Residual thermo-mechanical defects not detected during normal room temperature testing or high temperature lot buy-off are removed.
- Anomalous high temperature parametric effects that may have been created during wafer fabrication or in subsequent manufacturing are removed.
- An AQL of 0.05% or better is guaranteed.

RELIABILITY THROUGH DESIGN

With increased component density in modern electronic products has come an increased concern with component failures in such products. Virtually all equipment manufacturers thoroughly exercise their products before shipment. This is designed to simulate, as closely as possible, field operating conditions. A high failure rate of discrete components at this level can dramatically increase manufacturing costs.

The most important factor affecting a component's reliability is its construction; i.e., the materials used and the method by which they are fabricated and assembled.

NATIONAL'S ON-GOING RELIABILITY IMPROVEMENT PROGRAM

Transistor reliability improvement at National Semiconductor is a continuous program.

Implementation of a program for field reliability improvement requires knowledge of field ambient and electrical environments and their influence on device performance. National's broad experience in commercial reliability programs has led to the development of an extensive in-house reliability monitoring program that permits us to monitor device performance under combinations of the following stresses:

- Thermal
- Thermo-Mechanical
- Mechanical
- Voltage
- Humidity

The data generated by these monitors is continually ranked and analyzed to determine appropriate corrective action necessary for any failure mechanisms noted. Rigorous analysis of SPC data that is routinely generated at critical stages of the fabrication and manufacturing process is integrated into the corrective actions loop. This continuous cycle of testing, analysis, and corrective action assures the continued improvement of transistor field reliability.

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1N34AS	1N4148
1N35	1N4454
1N36	1N4148
1N38	1N4148
1N38A	1N3070
1N38B	1N3070
1N39	1N3070
1N39B	1N3070
1N39B	1N3070
1N40	1N4148
1N41	1N4454
1N42	1N3070
1N43	1N4148
1N44	1N3070
1N45	1N4454
1N46	1N4454
1N47	1N3070
1N48	1N4454
1N49	1N4148
1N50	1N4148
1N51	1N4454
1N52	1N4454
1N52A	1N4454
1N54	1N4148
1N54A	1N4148
1N55	1N3070
1N55A	1N3070
1N55B	1N3070
1N56	1N4148
1N56A	1N4148
1N57	1N4454
1N57A	1N4454
1N58	1N3070
1N58A	1N3070
1N61	1N3070
1N62	1N3070
1N63	1N4148
1N63A	1N4148
1N64	1N4148
1N64A	1N4148
1N65	1N4454
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1N66A	1N4454
1N67	1N4148
1N67A	1N4148
1N68	1N3070
1N68A	1N3070
1N69	1N4454
1N69A	1N4454
1N70	1N3070
1N70A	1N4148
1N71	FDH900
1N74	1N4148
1N75	1N3070
1N81	1N4305
1N81	1N4148
1N84	1N4148
1N86	1N4148
1N87	1N4148
1N87A	1N4148
1N87S	1N4148
1N87T	1N4148
1N88	1N3070
1N89	1N4454
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1N97A	1N4447
1N98	1N4454
1N98A	1N4448
1N99	1N4148
1N99A	1N4454
1N100	1N4447
1N100A	1N4448
1N101	1N3070
1N102	1N3070
1N103	1N4448
1N104	1N4448
1N107	FDH999
1N108	1N4448
1N111	1N4148
1N112	1N4148
1N113	1N4454
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1N115	1N4454
1N116	1N4454
1N116A	1N4454
1N117	1N4454
1N117A	1N4454
1N118	1N4454
1N118A	1N4448
1N119	1N4148
1N120	1N4148
1N126	1N4148
1N126A	1N4148
1N127	1N3070
1N127A	1N3070
1N128	1N4148
1N128A	1N4148
1N132	1N4148
1N133	1N4148
1N134	1N4454
1N135	1N4148
1N137A	1N483B
1N137B	1N483B
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1N266	1N4148
1N267	1N4148
1N268	1N4148

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Industry Device	NS Device
1N270	FDH444
1N273	1N4448
1N276	1N4454
1N277	1N3070
1N277M	1N4448
1N278	1N4446
1N279	1N4448
1N281	1N4448
1N282	1N4449
1N283	FDH444
1N287	1N4148
1N288	1N4148
1N289	1N4148
1N290	1N3070
1N291	1N3070
1N292	1N4448
1N294	1N4148
1N294A	1N4148
1N295	1N4148
1N295A	1N4148
1N295S	1N4148
1N295X	1N4148
1N296	1N4148
1N297	1N4148
1N297A	1N4148
1N298	1N4148
1N298A	1N4148
1N299	1N4305
1N300	1N482B
1N300A	1N482B
1N301	1N457
1N301A	1N457
1N301B	1N457
1N303	1N458
1N303A	1N484B
1N303B	1N484B
1N304	1N4148
1N307	1N4938
1N309	1N4148
1N310	1N4148
1N312	1N4448
1N313	1N4148
1N314	1N4148
1N330	1N456
1N331	1N458
1N337	2N2221
1N350	1N457
1N351	1N484B
1N352	1N485B
1N355	1N4148
1N373	1N5227A
1N375	1N5230A

Industry Device	NS Device
1N376	1N5233A
1N377	1N4148
1N378	1N5238A
1N385	1N4148
1N386	1N4148
1N387	1N4148
1N388	1N4148
1N389	1N4148
1N390	1N4148
1N391	1N4148
1N392	1N4148
1N393	1N3070
1N394	1N3070
1N417	1N4448
1N418	1N4148
1N419	FDH444
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1N432	1N4148
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1N434	1N3070
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1N435	1N4148
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1N448	1N4449
1N450	1N4151
1N451	1N3070
1N452	1N4448
1N453	1N3070
1N454	FDH444
1N456	1N456
1N456A	1N456A
1N457	1N457
1N457A	1N457A
1N457M	1N457
1N458	1N458
1N458A	1N458A
1N458M	1N458
1N459	1N459
1N459A	1N459A
1N459M	1N459
1N460	1N4148
1N460A	1N4148
1N460B	1N4448
1N461	1N461A
1N461A	1N461A
1N462	1N462A
1N462A	1N462A

Industry Device	NS Device
1N463	1N463A
1N463A	1N463A
1N464	1N463A
1N464A	1N463A
1N478	1N4148
1N479	1N4148
1N480	1N4148
1N482	1N482B
1N482A	1N482B
1N482B	1N482B
1N482C	1N482B
1N483	1N483B
1N483A	1N483B
1N483B	1N483B
1N483C	1N483B
1N484	1N484B
1N484A	1N484B
1N484B	1N484B
1N484C	1N484B
1N485	1N485B
1N485A	1N485B
1N485B	1N485B
1N485C	1N485B
1N490	1N4148
1N497	1N4448
1N498	1N4448
1N499	1N4448
1N500	1N4448
1N501	1N4448
1N502	1N3070
1N520B	1N457
1N527	1N4305
1N541	1N4305
1N542	1N4305
1N566	1N3070
1N567	1N3070
1N568	1N4305
1N569	1N4305
1N571	FDH444
1N616	1N4148
1N617	1N4148
1N618	1N4148
1N619	1N4148
1N622	1N4938
1N625	1N625
1N625A	1N4148
1N625M	1N625
1N626	1N626
1N626A	1N4148
1N626M	1N626
1N627	1N627
1N627A	1N3070

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N628	1N628
1N628A	1N3070
1N629	1N629
1N629A	1N3070
1N631	1N4148
1N632	1N4148
1N633	1N3070
1N634	1N3070
1N635	1N3070
1N636	1N4448
1N658	1N658
1N658A	1N658
1N659	1N659
1N659A	1N659
1N660	1N660
1N660A	1N660
1N661	1N661
1N661A	1N661
1N664	1N5237A
1N665	1N5242A
1N666	1N5245B
1N667	1N5248A
1N668	1N5251A
1N669	1N5245A
1N695	1N4148
1N695A	1N4148
1N696	1N4148
1N698	1N4305
1N699	1N4448
1N703	1N5227A
1N703A	1N5227B
1N704	1N5229A
1N704A	1N5229B
1N705	1N5230A
1N705A	1N5230B
1N706	1N5232A
1N706A	1N5232B
1N707	1N5236A
1N707A	1N5236B
1N708	1N5232A
1N708A	1N5232B
1N709	1N5234A
1N709A	1N5234B
1N710	1N5235A
1N710A	1N5235B
1N711	1N5236A
1N711A	1N5236B
1N712	1N5237A
1N712A	1N5237B
1N713	1N5239A
1N713A	1N5239B
1N714	1N5240A
1N714A	1N5240B
1N715	1N5241A
1N715A	1N5241B
1N716	1N5242A
1N716A	1N5242B
1N717	1N5243A
1N717A	1N5243B
1N718	1N5245A
1N718A	1N5245B
1N719	1N5246A
1N719A	1N5246B
1N720	1N5248A
1N720A	1N5248B
1N721	1N5250A
1N721A	1N5250B
1N722	1N5251A
1N722A	1N5251B
1N723	1N5252A
1N723A	1N5252B
1N724	1N5254A
1N724A	1N5254B
1N725	1N5256A
1N725A	1N5256B
1N726	1N5257A
1N726A	1N5257B
1N746	1N746A
1N746A	1N746A
1N747	1N747A
1N747A	1N747A
1N748	1N748A
1N748A	1N748A
1N749	1N749A
1N749A	1N749A
1N750	1N750A
1N750A	1N750A
1N751	1N751A
1N751A	1N751A
1N752	1N752A
1N752A	1N752A
1N753	1N753A
1N753A	1N753A
1N754	1N754A
1N754A	1N754A
1N755	1N755A
1N755A	1N755A
1N756	1N756A
1N756A	1N756A
1N757	1N757A
1N757A	1N757A
1N758	1N758A
1N758A	1N758A
1N759	1N759A
1N759A	1N759A
1N761	1N5230A
1N762	1N5232B
1N763	1N5238B
1N764	1N5238A
1N765	1N5240A
1N766	1N5243A
1N767	1N5246A
1N768	1N5249A
1N769	1N5252A
1N770	1N4305
1N771	1N4448
1N771A	FDH444
1N772	1N4448
1N772A	FDH444
1N773	1N4448
1N773A	FDH444
1N774	1N4448
1N774A	FDH444
1N775	1N4448
1N776	1N4448
1N777	1N4448
1N778	1N4148
1N779	1N3070
1N781	1N4305
1N781A	1N4305
1N788	1N4448
1N789	1N4148
1N789M	1N4148
1N790	1N4148
1N790M	1N4148
1N791	1N4448
1N791M	1N4448
1N792	1N4448
1N792M	1N4448
1N793	1N4148
1N793M	1N4148
1N794	1N4148
1N795	1N4448
1N796	1N4448
1N797	1N3070
1N798	1N3070
1N799	1N3070
1N800	1N3070
1N801	1N3070
1N802	1N3070
1N803	1N3070
1N804	1N3070
1N805	1N4148
1N806	1N4148
1N807	1N3070
1N808	1N4448

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N809	1N3070
1N810	1N4148
1N811	1N4148
1N811M	1N4148
1N812	1N4149
1N812M	1N4149
1N813	1N4148
1N813M	1N4148
1N814	1N4148
1N814M	1N4148
1N815	1N4448
1N815M	1N4448
1N817	1N3070
1N818	1N4148
1N818A	1N4148
1N835	1N4305
1N837	FDH444
1N837A	FDH444
1N838	1N3070
1N839	1N3070
1N840	FDH444
1N840M	1N3070
1N841	1N3070
1N842	1N3070
1N843	1N3070
1N844	1N3070
1N845	1N3070
1N890	1N4447
1N891	1N4448
1N892	1N4448
1N893	1N3070
1N897	1N4148
1N898	1N4448
1N899	1N3070
1N900	1N3070
1N901	1N3070
1N902	1N3070
1N903	1N4148
1N903A	1N4154
1N903AM	1N4154
1N903M	1N4154
1N904	1N4154
1N904A	1N4154
1N904AM	1N4154
1N904M	1N4154
1N905	1N4151
1N905A	1N4154
1N905AM	1N4154
1N905M	1N4154
1N906	1N4149
1N906A	1N4447
1N906AM	1N4447
1N906M	1N4447
1N907	1N4149
1N907A	1N4448
1N907AM	1N4447
1N907M	1N4149
1N908	1N4149
1N908A	1N4447
1N908AM	1N4447
1N908M	1N4149
1N909	1N4449
1N910	1N4449
1N911	1N4449
1N914	1N914
1N914A	1N914A
1N914B	1N914B
1N914M	1N914
1N915	1N914B
1N916	1N916
1N916A	1N916A
1N916B	1N916B
1N918	1N914
1N919	1N3070
1N920	FDH400
1N921	FDH400
1N922	FDH400
1N923	FDH400
1N924	1N483B
1N925	1N4148
1N926	1N4148
1N927	1N4148
1N928	1N3070
1N930	1N4446
1N931	1N3070
1N932	1N3070
1N933	1N3070
1N934	1N3070
1N948	1N4448
1N949	1N4305
1N957	1N957
1N957A	1N957A
1N957B	1N857B
1N958	1N958
1N958A	1N958A
1N958B	1N958B
1N959	1N959
1N959A	1N959A
1N959B	1N959B
1N960	1N960
1N960A	1N960A
1N960B	1N960B
1N961	1N961
1N961A	1N961A
1N961B	1N961B
1N962	1N962
1N962A	1N962A
1N962B	1N962B
1N963	1N963
1N963A	1N963A
1N963B	1N963B
1N964	1N964
1N964A	1N964A
1N964B	1N964B
1N965	1N965
1N965A	1N965A
1N965B	1N965B
1N966	1N966
1N966A	1N966A
1N966B	1N966B
1N967	1N967
1N967A	1N967A
1N967B	1N967B
1N968	1N968
1N968A	1N968A
1N968B	1N968B
1N969	1N969
1N969A	1N969A
1N969B	1N969B
1N970	1N970
1N970A	1N970A
1N970B	1N970B
1N971	1N971
1N971A	1N971A
1N971B	1N971B
1N972	1N972
1N972A	1N972A
1N972B	1N972B
1N973	1N973
1N973A	1N973A
1N973B	1N973B
1N993	1N4447
1N994	1N4151
1N995	1N4305
1N997	1N4148
1N998	1N484B
1N999	1N914
1N1093	FDH999
1N1170	1N4148
1N1374	1N5229A

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N1507	1N4730
1N1507A	1N4730A
1N1508	1N4732
1N1508A	1N4732A
1N1509	1N4734
1N1509A	1N4734A
1N1510	1N4736
1N1510A	1N4736A
1N1511	1N4738
1N1511A	1N4738A
1N1512	1N4740
1N1512A	1N4740A
1N1513	1N4742
1N1513A	1N4742A
1N1514	1N4744
1N1514A	1N4744A
1N1515	1N4746
1N1515A	1N4646A
1N1516	1N4748
1N1516A	1N4748A
1N1517	1N4750
1N1517A	1N4750A
1N1518	1N4730
1N1518A	1N4730A
1N1519	1N4732
1N1519A	1N4732A
1N1520	1N4734
1N1520A	1N4734A
1N1521A	1N4736A
1N1522	1N4738
1N1522A	1N4738A
1N1523	1N4740
1N1523A	1N4740A
1N1524	1N4742
1N1524A	1N4742A
1N1525	1N4744
1N1525A	1N4744A
1N1526	1N4746
1N1526A	1N4746A
1N1527A	1N4748A
1N1528	1N4750
1N1528A	1N4750A
1N1561	1N4305
1N1562	1N4305
1N1744	1N4740
1N1744A	1N4743A
1N1765A	1N4734A
1N1766	1N4735
1N1766A	1N4735A
1N1767	1N4736
1N1767A	1N4736A
1N1768	1N4737
1N1768A	1N4737A
1N1769	1N4738
1N1769A	1N4738A
1N1770	1N4739
1N1770A	1N4739A
1N1771	1N4740
1N1771A	1N4740A
1N1772	1N4741
1N1772A	1N4741A
1N1773	1N4742
1N1773A	1N4742A
1N1775	1N4744
1N1775A	1N4744A
1N1776	1N4745
1N1776A	1N4745A
1N1777	1N4746
1N1777A	1N4746A
1N1778	1N4747
1N1778A	1N4747A
1N1779	1N4748
1N1779A	1N4748A
1N1780	1N4749
1N1780A	1N4749A
1N1781	1N4750
1N1781A	1N4750A
1N1782	1N4751
1N1782A	1N4751A
1N1783	1N4752
1N1783A	1N4752A
1N1839	2N2218
1N1875	1N4738
1N1876	1N4740
1N1877	1N4742
1N1878	1N4744
1N1879	1N4746
1N1880	1N4748
1N1881	1N4750
1N1882	1N4752
1N1927	1N5228A
1N1928	1N5230A
1N1929	1N5232A
1N1930	1N5235A
1N1931	1N5237A
1N1932	1N5240A
1N1933	1N5242A
1N1934	1N5245A
1N1935	1N5248A
1N1936	1N5251A
1N1954	1N5228A
1N1955	1N5230A
1N1956	1N5232A
1N1957	1N5235A
1N1958	1N5237A
1N1959	1N5240A
1N1960	1N5242A
1N1961	1N5245A
1N1962	1N5248A
1N1963	1N5251A
1N1981	1N5228A
1N1982	1N5230A
1N1983	1N5232A
1N1984	1N5235A
1N1985	1N5237A
1N1986	1N5240A
1N1987	1N5242A
1N1988	1N5245A
1N1989	1N5248A
1N1990	1N5251A
1N2032	1N4732
1N2033	1N4734
1N2034	1N4736
1N2035	1N4739
1N2036	1N4740
1N2037	1N4743
1N2038	1N4745
1N2039	1N4747
1N2040	1N4749
1N2146	FDH400
1N2629	1N4305
1N3016	1N4736
1N3016A	1N4736A
1N3016B	1N4736B
1N3017	1N4737
1N3017A	1N4737A
1N3017B	1N4737B
1N3018	1N4738
1N3018A	1N4738
1N3018B	1N4738A
1N3019	1N4739
1N3019A	1N4739
1N3019B	1N4739A
1N3020	1N4740
1N3020A	1N4740
1N3020B	1N4740A
1N3021	1N4741
1N3021A	1N4741
1N3021B	1N4741A
1N3022	1N4742

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N3022A	1N4742
1N3022B	1N4742A
1N3023	1N4743
1N3023A	1N4743
1N3023B	1N4743A
1N3024	1N4744
1N3024A	1N4744
1N3024B	1N4744A
1N3025	1N4745
1N3025A	1N4745
1N3025B	1N4745A
1N3026	1N4746
1N3026A	1N4746
1N3026B	1N4746A
1N3027	1N4747
1N3027A	1N4747
1N3027B	1N4747A
1N3028	1N4748
1N3028A	1N4748
1N3028B	1N4748A
1N3029	1N4749
1N3029A	1N4749
1N3029B	1N4749A
1N3030	1N4750
1N3030A	1N4750
1N3030B	1N4750A
1N3031	1N4751
1N3031A	1N4751
1N3031B	1N4751A
1N3032	1N4752
1N3032A	1N4752
1N3032B	1N4752A
1N3062	1N4305
1N3063	1N4305
1N3064	1N3064
1N3065	1N4305
1N3066	1N4305
1N3067	1N4148
1N3068	1N4148
1N3069	1N4148
1N3070	1N3070
1N3071	1N3070
1N3097	1N4305
1N3110	1N4305
1N3121	1N4305
1N3122	1N4305
1N3123	1N4305
1N3124	1N4151
1N3125	1N4305
1N3144	1N4305

Industry Device	NS Device
1N3145	1N4305
1N3146	1N4154
1N3147	1N4448
1N3160	1N4305
1N3179	1N3070
1N3180	1N3070
1N3181	1N5237A
1N3197	1N4148
1N3203	1N4305
1N3204	1N4305
1N3206	1N4148
1N3215	1N4152
1N3223	1N3070
1N3225	1N4148
1N3257	1N4449
1N3258	1N4448
1N3298	FDH400
1N3298A	FDH400
1N3465	FDH444
1N3266	FDH444
1N3467	1N4446
1N3468	1N4446
1N3469	FDH400
1N3470	FDH400
1N3471	1N4148
1N3483	1N4305
1N3484	1N4305
1N3485	1N3070
1N3535	1N3070
1N3536	1N457
1N3550	1N3070
1N3559	FDH444
1N3564	1N4448
1N3567	1N4448
1N3568	1N4449
1N3575	1N483B
1N3576	1N484B
1N3592	1N4305
1N3593	1N4148
1N3594	FDH600
1N3595	1N3595
1N3596	1N4449
1N3597	1N3070
1N3598	1N4152
1N3599	1N4938
1N3600	1N3600
1N3601	1N4149
1N3602	1N4151
1N3603	1N4151
1N3604	1N4151

Industry Device	NS Device
1N3605	1N4152
1N3606	1N4153
1N3607	1N4151
1N3608	1N4152
1N3609	1N4153
1N3625	1N3070
1N3638B	1N4744A
1N3653	FDH400
1N3654	1N4448
1N3666	1N4305
1N3668	1N4305
1N3675	1N4736
1N3675A	1N4736
1N3675B	1N4736A
1N3676	1N4737
1N3676A	1N4737
1N3676B	1N4737A
1N3677	1N4738
1N3677A	1N4738
1N3677B	1N4738A
1N3678	1N4739
1N3678A	1N4739
1N3678B	1N4739A
1N3679	1N4740
1N3679A	1N4740
1N3679B	1N4740A
1N3680	1N4741
1N3680A	1N4741
1N3680B	1N4741A
1N3681	1N4742
1N3681A	1N4742
1N3681B	1N4742A
1N3682	1N4743
1N3682A	1N4743
1N3682B	1N4743A
1N3683	1N4744
1N3683A	1N4744
1N3684	1N4745
1N3684A	1N4745
1N3684B	1N4745A
1N3685	1N4746
1N3685A	1N4746
1N3685B	1N4746A
1N3686	1N4747
1N3686A	1N4747
1N3686B	1N4747A
1N3687	1N4748
1N3687A	1N4748
1N3687B	1N4748A
1N3688	1N4749

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N3688A	1N4749
1N3689	1N4750
1N3689A	1N4750
1N3689B	1N4750A
1N3690	1N4751
1N3690A	1N4751
1N3690B	1N4751A
1N3691	1N4752
1N3691A	1N4752
1N3691B	1N4752A
1N3722	1N4148
1N3731	1N4153
1N3753	1N4148
1N3769	1N4305
1N3773	1N4305
1N3821	1N4728
1N3821A	1N4728A
1N3822	1N4729
1N3722A	1N4729A
1N3823	1N4730
1N3823A	1N4730A
1N3824	1N4731
1N3824A	1N4731A
1N3825	1N4732
1N3825A	1N4732A
1N3826	1N4733
1N3826A	1N4733A
1N3827	1N4734
1N3827A	1N4734A
1N3828	1N4735
1N3828A	1N4735A
1N3929	1N4736
1N3829A	1N4736A
1N3830	1N4737
1N3830A	1N4737A
1N3864	1N458
1N3865	1N4148
1N3872	FDH444
1N3873	FDH444
1N3944	1N4305
1N3952	1N3070
1N3953	1N4148
1N3954	1N4150
1N3956	1N4305
1N3991	1N4305
1N4008	1N4305
1N4009	1N4009
1N4043	1N4154
1N4086	FDH444
1N4087	FDH900
1N4088	1N4148
1N4147	1N914
1N4147A	1N4752
1N4147B	1N4752A
1N4148	1N4148
1N4149	1N4149
1N4150	1N4150
1N4151	1N4151
1N4152	1N4152
1N4153	1N4153
1N4154	1N4154
1N4158	1N4736
1N4158A	1N4736
1N4158B	1N4736A
1N4159	1N4737
1N4161	1N4739
1N4161A	1N4739
1N4161B	1N4739A
1N4162	1N4740
1N4162A	1N4740
1N4162B	1N4740A
1N4163	1N4741
1N4163A	1N4741
1N4163B	1N4741A
1N4164	1N4742
1N4164A	1N4742
1N4164B	1N4742A
1N4165	1N4743
1N4165A	1N4743
1N4165B	1N4743A
1N4166	1N4744
1N4166A	1N4744
1N4166B	1N4744A
1N4167	1N4745
1N4167A	1N4745
1N4167B	1N4745A
1N4168	1N4746
1N4168A	1N4746
1N4166B	1N4746A
1N4169	1N4747
1N4169A	1N4747
1N4169B	1N4747A
1N4170	1N4748
1N4170A	1N4748
1N4170B	1N4748A
1N4171	1N4749
1N4171A	1N4749
1N4171B	1N4749A
1N4172	1N4750
1N4172A	1N4750
1N4172B	1N4750A
1N4173	1N4751
1N4173A	1N4751
1N4173B	1N4751A
1N4242	FDH900
1N4243	FDH900
1N4244	1N4244
1N4254	1N4305
1N4305	1N4305
1N4306	1N4306
1N4307	1N4307
1N4308	1N4150
1N4309	FDH400
1N4310	FDH400
1N4312	FDH444
1N4313	1N4151
1N4314	1N4150
1N4315	FDH400
1N4316	FDH400
1N4318	FDH444
1N4319	1N4151
1N4322	1N4150
1N4323	1N4736
1N4323B	1N4736A
1N4324	1N4737
1N4324A	1N4737
1N4324B	1N4737A
1N4325	1N4738
1N4325A	1N4738
1N4325B	1N4738A
1N4326	1N4739
1N4326A	1N4739
1N4326B	1N4739A
1N4327	1N4740
1N4327A	1N4740
1N4327B	1N4740A
1N4328	1N4741
1N4328A	1N4741
1N4328B	1N4741A
1N4329	1N4742
1N4329A	1N4742
1N4329B	1N4742A
1N4330	1N4743
1N4330A	1N4743
1N4330B	1N4743A
1N4331	1N4744
1N4331A	1N4744
1N4331B	1N4744A
1N4332	1N4745
1N4332A	1N4745

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N4332B	1N4745A
1N4333	1N4746
1N4333A	1N4746
1N4333B	1N4746A
1N4334	1N4747
1N4334A	1N4747
1N4334B	1N4747A
1N4335	1N4748
1N4335A	1N4748
1N4335B	1N4748A
1N4336	1N4749
1N4336A	1N4749
1N4336B	1N4749A
1N4337	1N4750
1N4337A	1N4750
1N4337B	1N4750A
1N4338	1N4751
1N4338A	1N4751
1N4338B	1N4751A
1N4339	1N4752
1N4339A	1N4752
1N4339B	1N4752A
1N4362	1N484B
1N4363	1N3070
1N4373	1N4148
1N4375	1N4153
1N4376	1N4376
1N4389	1N4148
1N4390	FD700
1N4391	FD700
1N4392	FD700
1N4400	1N4736
1N4401	1N4737
1N4402	1N4738
1N4403	1N4739
1N4404	1N4740
1N4405	1N4741
1N4406	1N4742
1N4407	1N4743
1N4408	1N4744
1N4409	1N4745
1N4410	1N4746
1N4411	1N4747
1N4412	1N4748
1N4413	1N4749
1N4414	1N4750
1N4415	1N4751
1N4416	1N4752
1N4424A	1N4736
1N4442	FDH999
1N4443	1N4148
1N4445	1N4151
1N4446	1N4446
1N4447	1N4447
1N4448	1N4448
1N4449	1N4449
1N4450	1N4450
1N4451	1N4151
1N4453	1N4448
1N4454	1N4454
1N4455	1N4305
1N4456	1N4150
1N4457	1N4150
1N4502	1N4305
1N4523	1N4305
1N4531	1N4148
1N4532	FDH600
1N4533	1N4152
1N4534	1N4153
1N4536	1N4154
1N4547	1N4151
1N4548	1N4154
1N4608	FDH400
1N4610	1N4150
1N4628	1N4736A
1N4629	1N4737A
1N4630	1N4738A
1N4631	1N4739A
1N4632	1N4740A
1N4633	1N4741A
1N4634	1N4742A
1N4635	1N4743A
1N4636	1N4744A
1N4637	1N4745A
1N4638	1N4746A
1N4639	1N4747A
1N4640	1N4748A
1N4641	1N4749A
1N4642	1N4750A
1N4643	1N4751A
1N4644	1N4752A
1N4649	1N4728A
1N4650	1N4729A
1N4651	1N4730A
1N4652	1N4731A
1N4653	1N4732A
1N4654	1N4733A
1N4655	1N4734A
1N4656	1N4735A
1N4657	1N4736A
1N4658	1N4737A
1N4659	1N4738A
1N4660	1N4739A
1N4661	1N4740A
1N4662	1N4741A
1N4663	1N4742A
1N4664	1N4743A
1N4665	1N4744A
1N4666	1N4745A
1N4667	1N4746A
1N4668	1N4747A
1N4669	1N4748A
1N4670	1N4749A
1N4671	1N4750A
1N4672	1N4751A
1N4673	1N4752A
1N4728	1N4728
1N4728A	1N4728A
1N4729	1N4729
1N4729A	1N4729A
1N4730	1N4730
1N4730A	1N4730A
1N4731	1N4731
1N4731A	1N4731A
1N4732	1N4732
1N4732A	1N4732A
1N4733	1N4733
1N4733A	1N4733A
1N4734	1N4734
1N4734A	1N4734A
1N4735	1N4735
1N4735A	1N4735A
1N4736	1N4736
1N4736A	1N4736A
1N4737	1N4737
1N4737A	1N4737A
1N4738	1N4738
1N4738A	1N4738A
1N4739	1N4739
1N4739A	1N4739A
1N4740	1N4740
1N4740A	1N4740A
1N4741	1N4741
1N4741A	1N4741A
1N4742	1N4742
1N4742A	1N4742A
1N4743	1N4743
1N4743A	1N4743A
1N4744	1N4744
1N4744A	1N4744A

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N4745	1N4745
1N4745A	1N4745A
1N4746	1N4746
1N4746A	1N4746A
1N4747	1N4747
1N4747A	1N4747A
1N4748	1N4748
1N4748A	1N4748A
1N4749	1N4749
1N4749A	1N4749A
1N4750	1N4750
1N4750A	1N4750A
1N4751	1N4751
1N4751A	1N4751A
1N4827	1N4448
1N4828	FDH444
1N4829	FDH444
1N4830	FDH444
1N4861	1N457
1N4862	1N457
1N4863	1N4148
1N4864	1N4151
1N4888	FD777
1N4938	1N3070
1N4949	FD777
1N4950	1N4150
1N4953	FD777
1N5194	1N483B
1N5195	1N485B
1N5209	1N458
1N5210	1N459
1N5219	FDH900
1N5220	FDH900
1N5226	1N5226
1N5226A	1N5226A
1N5226B	1N5226B
1N5227	1N5227
1N5227A	1N5227A
1N5227B	1N5227B
1N5228	1N5228
1N5228A	1N5228A
1N5228B	1N5228B
1N5229	1N5229
1N5229A	1N5229A
1N5229B	1N5229B
1N5230	1N5230
1N5230A	1N5230A
1N5230B	1N5230B
1N5231	1N5231
1N5231A	1N5231A
1N5231B	1N5231B
1N5232	1N5232
1N5232A	1N5232A
1N5232B	1N5232B
1N5233	1N5233
1N5233B	1N5233B
1N5234	1N5234
1N5234A	1N5234A
1N5234B	1N5234B
1N5235	1N5235
1N5235A	1N5235A
1N5235B	1N5235B
1N5236	1N5236
1N5236A	1N5236A
1N5236B	1N5236B
1N5237	1N5237
1N5237A	1N5237A
1N5237B	1N5237B
1N5238	1N5238
1N5238A	1N5238A
1N5238B	1N5238B
1N5239	1N5239
1N5239A	1N5239A
1N5239B	1N5239B
1N5240	1N5240
1N5240A	1N5240A
1N5240B	1N5240B
1N5241	1N5241
1N5241A	1N5241A
1N5241B	1N5241B
1N5242	1N5242
1N5242A	1N5242A
1N5242B	1N5242B
1N5243	1N5243
1N5243A	1N5243A
1N5243B	1N5243B
1N5244	1N5244
1N5244A	1N5244A
1N5244B	1N5244B
1N5245	1N5245
1N5245A	1N5245A
1N5245B	1N5245B
1N5246	1N5246
1N5246A	1N5246A
1N5246B	1N5246B
1N5247	1N5247
1N5247A	1N5247A
1N5247B	1N5247B
1N5248	1N5248
1N5248A	1N5248A
1N5248B	1N5248B
1N5249	1N5249
1N5249A	1N5249A
1N5249B	1N5249B
1N5250	1N5250
1N5250A	1N5250A
1N5250B	1N5250B
1N5251	1N5251
1N5251A	1N5251A
1N5251B	1N5251B
1N5252	1N5252
1N5252A	1N5252A
1N5252B	1N5252B
1N5253	1N5253
1N5253A	1N5253A
1N5253B	1N5253B
1N5254	1N5254
1N5254A	1N5254A
1N5254B	1N5254B
1N5255	1N5255
1N5255A	1N5255A
1N5255B	1N5255B
1N5256	1N5256
1N5256A	1N5256A
1N5256B	1N5256B
1N5257	1N5257
1N5257A	1N5257A
1N5257B	1N5257B
1N5282	1N5282
1N5315	1N4153
1N5316	1N4153
1N5317	1N4150
1N5318	1N4150
1N5319	1N4305
1N5412	1N4305
1N5413	1N4305
1N5414	1N4305
1N5427	1N4148
1N5428	1N3070
1N5249	1N485B
1N5430	FDH400
1N5431	FDH400
1N5432	FD777
1N5559	1N4736
1N5559A	1N4736
1N5559B	1N4736A
1N5560	1N4737
1N5561	1N4738
1N5561A	1N4738
1N5561B	1N4738A

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N5562	1N4739
1N5562A	1N4739
1N5562B	1N4739A
1N5563	1N4740
1N5563A	1N4740
1N5563B	1N4740A
1N5564	1N4741
1N5564A	1N4741
1N5564B	1N4741A
1N5565	1N4742
1N5565A	1N4742
1N5565B	1N4742A
1N5566	1N4743
1N5566A	1N4743
1N5566B	1N4743A
1N5567	1N4744
1N5567A	1N4744
1N5567B	1N4744A
1N5568	1N4745
1N5568A	1N4745
1N5568B	1N4745A
1N5569	1N4746
1N5569A	1N4746
1N5569B	1N4746A
1N5570	1N4747
1N5570A	1N4747
1N5570B	1N4747A
1N5571	1N4748
1N5571A	1N4748
1N5571B	1N4748A
1N5572	1N4749
1N5572A	1N4749
1N5572B	1N4749A
1N5573	1N4750
1N5573A	1N4750
1N5573B	1N4750A
1N5574	1N4751
1N5574A	1N4751
1N5574B	1N4751A
1N5575	1N4752
1N5575A	1N4752
1N5575B	1N4752A
1N5605	1N457
1N5606	1N458
1N5607	1N3070
1N5608	1N3070
1N5609	1N3070
1N5660A	1N4737
1N5660B	1N4737A
1N5711	1N4446

Industry Device	NS Device
1N5712	1N4446
1N5713	1N4446
1N5719	1N484
1N5720	1N4448
1N5721	1N4448
1N5726	FDH400
1N5767	1N4448
1N5768	1N5768
1N5769	FSA2002M
1N5770	1N5770
1N5771	FSA2003M
1N5772	1N5772
1N5773	FSA2500M
1N5774	1N5774
1N5775	FSA2504M
1N5913	1N4728
1N5913A	1N4728
1N5914	1N4729
1N5914A	1N4729
1N5914B	1N4729A
1N5915	1N4730
1N5915A	1N4730
1N5915B	1N4730A
1N5916	1N4731
1N5916A	1N4731
1N5916B	1N4731A
1N5917	1N4732
1N5917A	1N4732
1N5917B	1N4732A
1N5918	1N4733
1N5918A	1N4733
1N5918B	1N4733A
1N5919	1N4734
1N5919A	1N4734
1N5919B	1N4734A
1N5920	1N4735
1N5920A	1N4735
1N5920B	1N4735A
1N5921	1N4736
1N5921A	1N4736
1N5921B	1N4736A
1N5922	1N4737
1N5922A	1N4737
1N5922B	1N4737A
1N5923	1N4738
1N5923A	1N4738
1N5923B	1N4738A
1N5924	1N4739
1N5924A	1N4739
1N5924B	1N4739A

Industry Device	NS Device
1N5925	1N4740
1N5925A	1N4740
1N5925B	1N4740A
1N5926	1N4741
1N5926A	1N4741
1N5926B	1N4741A
1N5927	1N4742
1N5927A	1N4742
1N5927B	1N4742A
1N5928	1N4743
1N5928A	1N4743
1N5928B	1N4743A
1N5929	1N4744
1N5929A	1N4744
1N5929B	1N4744A
1N5930	1N4745
1N5930A	1N4745
1N5930B	1N4745A
1N5931	1N4746
1N5931A	1N4746
1N5931B	1N4728A
1N5932	1N4747
1N5932A	1N4747
1N5932B	1N4747A
1N5933	1N4748
1N5933A	1N4748
1N5933B	1N4748A
1N5934	1N4749
1N5934A	1N4749
1N5934B	1N4749A
1N5935	1N4750
1N5935A	1N4750
1N5935B	1N4750A
1N5936	1N4751
1N5936A	1N4751
1N5936B	1N4751A
1N5937	1N4752
1N5937A	1N4752
1N5937B	1N4752A
1N5988	1N5226
1N5988A	1N5226A
1N5989	1N5227
1N5989A	1N5227A
1N5989B	1N5227B
1N5990A	1N5228A
1N5990B	1N5228B
1N5991	1N5229
1N5991A	1N5229A
1N5991B	1N5229B
1N5992	1N5230

Diode Device Cross Reference (Continued))

Industry Device	NS Device
1N5992A	1N5230A
1N5992B	1N5230B
1N5993	1N5231
1N5993A	1N5231A
1N5993B	1N5231B
1N5994	1N5232
1N5994A	1N5232A
1N5994B	1N5232B
1N5995	1N5234
1N5995A	1N5234A
1N5995B	1N5234B
1N5996	1N5235
1N5996A	1N5235A
1N5996B	1N5235B
1N5997	1N5236
1N5997A	1N5236A
1N5997B	1N5236B
1N5998	1N5237
1N5998A	1N5237A
1N5998B	1N5226B
1N5998B	1N5237B
1N5999	1N5239
1N5999A	1N5239A
1N5999B	1N5239B
1N6000	1N5240
1N6000A	1N5240A
1N6000B	1N5240B
1N6001	1N5241
1N6001A	1N5241A
1N6001B	1N5241B
1N6002	1N5242
1N6002A	1N5242A
1N6002B	1N5242B
1N6003	1N5243
1N6003A	1N5243A
1N6003B	1N5243B
1N6004	1N5245
1N6004A	1N5245A
1N6004B	1N5245B
1N6005	1N5246
1N6005A	1N5246A
1N6005B	1N5246B
1N6006	1N5248
1N6006A	1N5248A
1N6006B	1N5248B
1N6007	1N5250
1N6007A	1N5250A
1N6007B	1N5250B
1N6008	1N5251
1N6008A	1N5251A
1N6008B	1N5251B
1N6009	1N5252
1N6009A	1N5252A
1N6009B	1N5252B
1N6010	1N5254
1N6010A	1N5254A
1N6010B	1N5254B
1N6011	1N5256
1N6011A	1N5256A
1N6011B	1N5256B
1N6012	1N5257
1N6012A	1N5257A
1N6012B	1N5257B
1N6099	1N6099
1N6100	1N6100
1N6101	1N6101
1N6496	1N6496
1S44	1S44
1S920	1S920
1S921	1S921
1S922	1S922
1S923	1S923
AA112	FDH999
AA113	BA128
AA114	BA130
AA116	BA130
AA129	BA130
AA131	FDH900
AA137	BA130
AA138	BA130
AA139	BA129
AAY10	BA130
AAY48	BA130
AAZ13	BA130
AAZ18	BA130
BA127	BA128
BA128	BA128
BA130	BA130
BA136	BA128
BA152	FDH900
BA154	FDH900
BA165	FDH900
BA166	BA130
BA167	BA130
BA192	FDH400
BA193	FDH400
BA194	FDH400
BA197	FDH400
BA198	FDH400
BA200	BA218
BA217	BA217
BA218	BA218
BA316	BA316
BA317	BA317
BA318	BA318
BAS13	FDH400
BAS19	BAS19
BAS20	BAS20
BAS21	BAS21
BAS36	FA2320E
BAS45	BAS45
BAV17	BAV17
BAV18	BAV18
BAV19	BAV19
BAV20	BAV20
BAV21	BAV21
BAV24	BAY74
BAV50	FSA2510M
BAV68	BAY72
BAV69	FDH400
BAW10	BAY74
BAW11	BAY72
BAW12	FDH444
BAW16	FDH300
BAW17	FDH300
BAW18	FDH300
BAW24	BAY74
BAW25	FDH600
BAW26	FDH600
BAW33	BAY72
BAW43	BAY73
BAW45	BAY71
BAW46	BAY72
BAW47	BAY72
BAW48	BAY71
BAW49	BAY73
BAW50	FDH400
BAW51	BAY72
BAW52	FDH400
BAW53	BAY74
BAW54	BAY74
BAW55	BAY72
BAW62	BAW62
BAW75	BAW75
BAW76	BAW76
BAW77	BAY72
BAX12	BAY74
BAX13	BAX13
BAX15	FDH400
BAX16	BAX16

Diode Device Cross Reference (Continued))

Industry Device	NS Device
BAX17	BAX17
BAX20	FDH444
BAX21	FDH444
BAX33	FA2310E
BAX34	FA2310E
BAX35	FA2310E
BAX37	FA2320E
BAX38	FA2320E
BAX39	FA4310E
BAX40	FA4310E
BAX41	FA4310E
BAX42	FA4320E
BAX43	FA4320E
BAX44	FA4320E
BAX83	BAY72
BAX84	BAY71
BAX85	BAY71
BAX86A	BAY71
BAX86B	BAY71
BAX87	BAY71
BAX89B	BAY71
BAX89H	BAY71
BAX90A	BAY71
BAX90B	BAY71
BAX91A	BAY71
BAX91B	BAY71
BAX91C	BAY71
BAX92	BAY71
BAX93	BAY71
BAX94	BAY71
BAY17	BAY72
BAY18	BAY72
BAY19	BAY72
BAY20	FDH400
BAY38	BAY71
BAY41	BAY71
BAY42	BAY71
BAY43	1N4148
BAY60	BAY74
BAY61	BAY74
BAY63	BAY74
BAY68	BAY74
BAY69	BAY74
BAY71	BAY71
BAY72	BAY72
BAY73	BAY73
BAY74	BAY74
BAY80	BAY80
BAY82	BAY82
BAY93	BAY71

Industry Device	NS Device
BAY94	BAY71
BAY95	BAY71
DA1701	1N4148
DA1702	1N4148
DA1703	1N4148
DA1704	1N4148
FA2310	FA2310
FA2311	FA2311
FA2312	FA2312
FA2313	FA2313
FA2320	FA2320
FA2321	FA2321
FA2322	FA2322
FA2323	FA2323
FA2324	FA2324
FA2325	FA2325
FA2330	FA2330
FA2331	FA2331
FA2332	FA2332
FA2333	FA2333
FA2334	FA2334
FA2335	FA2335
FA2360	FA2360
FA2361	FA2361
FA3310	FA3310
FA3311	FA3311
FA3312	FA3312
FA3313	FA3313
FA3320	FA3320
FA3321	FA3321
FA3322	FA3322
FA3323	FA3323
FA3324	FA3324
FA3325	FA3325
FA3330	FA3330
FA3331	FA3331
FA3332	FA3332
FA3333	FA3333
FA3334	FA3334
FA3335	FA3335
FA3360	FA3360
FA3361	FA3361
FA4310	FA4310
FA4311	FA4311
FA4312	FA4312
FA4313	FA4313
FA4320	FA4320
FA4321	FA4321
FA4322	FA4322
FA4323	FA4323

Industry Device	NS Device
FA4324	FA4324
FA4325	FA4325
FA4330	FA4330
FA4331	FA4331
FA4332	FA4332
FA4333	FA4333
FA4334	FA4334
FA4335	FA4335
FA4360	FA4360
FA4361	FA4361
FD300	FDH300
FD333	FDH333
FD400	FDH400
FD444	FDH444
FD600	FDH600
FD666	FDH666
FD700	FD700
FD777	FD777
FD1389	FD1389
FD2389	FD2389
FD3389	FD3389
FD6389	FD6389
FDH300	FDH300
FDH333	FDH333
FDH400	FDH400
FDH444	FDH444
FDH600	FDH600
FDH666	FDH666
FDH900	FDH900
FDH999	FDH999
FDH1000	FDH1000
FDN400	FDH400
FDN444	FDH444
FDN600	FDH600
FDN666	FDH666
FDN700	FD700
FDN777	FD777
FJT1100	FJT1100
FJT1101	FJT1101
FSA2002M	FSA2002M
FSA2003M	FSA2003M
FSA2500M	FSA2500M
FSA2501M	FSA2501M
FSA2501P	FSA2501P
FSA2502M	FSA2502M
FSA2503M	FSA2503M
FSA2503P	FSA2503P
FSA2504M	FSA2504M
FSA2509M	FSA2509M
FSA2509P	FSA2509P

Diode Device Cross Reference (Continued))

Industry Device	NS Device
FSA2510M	FSA2510M
FSA2510P	FSA2510P
FSA2563M	FSA2563M
FSA2563P	FSA2563P
FSA2564M	FSA2564M
FSA2564P	FSA2564P
FSA2565M	FSA2565M
FSA2565P	FSA2565P
FSA2566M	FSA2566M
FSA2566P	FSA2566P
FSA2619M	FSA2619M
FSA2619P	FSA2619P
FSA2620M	FSA2620M
FSA2620P	FSA2620P
FSA2621M	FSA2621M
FSA2719M	FSA2719M
FSA2719P	FSA2719P
FSA2720M	FSA2720M
FSA2720P	FSA2720P
FSA2721M	FSA2721M
FSA2721P	FSA2721P
MC1103L	FSA2501M
MC1103P	FSA2501
MC1105F	FSA2502M
MC1105L	FSA2563M
MC1105P	FSA2563
MC1106F	FSA2003M
MC1106L	FSA2564M

Industry Device	NS Device
MC1106P	FSA2564
MC1107F	FSA2504M
MC1107L	FSA2503M
MC1107P	FSA2503
MC1103F	FSA2500M
TID21A	FSA2002M
TID22A	FSA2002M
TID23A	FSA2003M
TID24A	FSA2003M
TID25A	FSA2500M
TID26A	FSA2500M
TID121	FSA2563M
TID122	FSA2563M
TID123	FSA2564M
TID124	FSA2564M
TID125	FSA2510M
TID126	FSA2510M
TID131	FSA2504M
TID132	FSA2504M
TID133	FSA2509M
TID134	FSA2509M
TID135N	FSA2510M
TID136N	FSA2510M
TID139F	FSA2721M
TID139N	FSA2720M
TID140F	FSA2721M
TID140N	FSA2720M

Diode Device Cross Reference

THRUHOLE → SURFACE MOUNT

Industry Device	NS LL-34	NS SO Outline
1N456	FDLL456	
1N456A	FDLL456A	
1N457	FDLL457	
1N457A	FDLL457A	
1N458	FDLL458	
1N458A	FDLL458A	
1N459	FDLL459	
1N459A	FDLL459A	
1N461A	FDLL461A	
1N462A	FDLL462A	
1N463A	FDLL463A	
1N482B	FDLL482B	
1N483B	FDLL483B	
1N484B	FDLL484B	
1N485B	FDLL485B	
1N625	FDLL625	
1N626	FDLL626	
1N627	FDLL627	
1N628	FDLL628	
1N629	FDLL629	
1N658	FDLL658	
1N659	FDLL659	
1N660	FDLL660	
1N661	FDLL661	
1N914A	FDLL914A	FDSO914
1N914B	FDLL914B	
1N916A	FDLL916A	
1N916B	FDLL916B	
1N920	FDLL920	
1N921	FDLL921	
1N922	FDLL922	
1N923	FDLL923	
1N3064	FDLL3064	
1N3070	FDLL3070	FDSO3070
1N3595	FDLL3595	FDSO3595
1N3600	FDLL3600	
1N4009	FDLL4009	
1N4148	FDLL4148	FDSO4148
1N4149	FDLL4149	
1N4150	FDLL4150	
1N4151	FDLL4151	
1N4152	FDLL4152	
1N4153	FDLL4153	
1N4154	FDLL4154	
1N4305	FDLL4305	
1N4446	FDLL4446	
1N4447	FDLL4447	
1N4448	FDLL4448	FDSO4448
1N4449	FDLL4449	
1N4450	FDLL4450	
1N4454	FDLL4454	
1N4938	FDLL4938	
1N5768		FASO5768
1N5770		FASO5770
1N5772		FASO5772
1N5774		FASO5774
1N6099	FDLL6099	
1N6101	FASO6101	
BAS16		BAS16
BAV70		BAV70
BAV74		BAV74
BAV99		BAV99
BAW56		BAW56
FASO2501		FASO2501
FASO2503		FASO2503
FASO2509		FASO2509
FASO2510		FASO2510
FASO2563		FASO2563
FASO2564		FASO2564
FASO2565		FASO2565
FASO2566		FASO2566
FASO2618		FASO2618
FASO2619		FASO2619
FASO2620		FASO2620
FASO2718		FASO2718
FASO2719		FASO2719
FASO2720		FASO2720
FASO5768		FASO5768
FASO5770		FASO5770
FASO5772		FASO5772
FASO5774		FASO5774
FASO6101		FASO6101
FDH300	FDLL300	
FDH333	FDLL333	
FDH400	FDLL400	
FDH444	FDLL444	
FDH600	FDLL600	
FDH666	FDLL666	
FDH700	FDLL700	
FDH777	FDLL777	
FDH900	FDLL900	
FDH999	FDLL999	
FDH1000	FDLL1000	
FDLL300	FDLL300	
FDLL333	FDLL333	
FDLL400	FDLL400	
FDLL444	FDLL444	
FDLL456	FDLL456	
FDLL456A	FDLL456A	

Diode Device Cross Reference (Continued))

THRUHOLE → SURFACE MOUNT

Industry Device	NS LL-34	NS SO Outline
FDLL457	FDLL457	
FDLL457A	FDLL457A	
FDLL458	FDLL458	
FDLL458A	FDLL458A	
FDLL459	FDLL459	
FDLL459A	FDLL459A	
FDLL461A	FDLL461A	
FDLL462A	FDLL462A	
FDLL463A	FDLL463A	
FDLL482B	FDLL482B	
FDLL483B	FDLL483B	
FDLL484B	FDLL484B	
FDLL485B	FDLL485B	
FDLL600	FDLL600	
FDLL625	FDLL625	
FDLL626	FDLL626	
FDLL627	FDLL627	
FDLL628	FDLL628	
FDLL629	FDLL629	
FDLL658	FDLL658	
FDLL659	FDLL659	
FDLL660	FDLL660	
FDLL661	FDLL661	
FDLL666	FDLL666	
FDLL700	FDLL700	
FDLL777	FDLL777	
FDLL900	FDLL900	
FDLL914A	FDLL914A	
FDLL914B	FDLL914B	
FDLL916A	FDLL916A	
FDLL916B	FDLL916B	
FDLL920	FDLL920	
FDLL921	FDLL921	
FDLL922	FDLL922	
FDLL923	FDLL923	
FDLL999	FDLL999	
FDLL1000	FDLL1000	
FDLL3064	FDLL3064	
FDLL3070	FDLL3070	

Industry Device	NS LL-34	NS SO Outline
FDLL3595	FDLL3595	
FDLL3600	FDLL3600	
FDLL4009	FDLL4009	
FDLL4148	FDLL4148	
FDLL4149	FDLL4149	
FDLL4150	FDLL4150	
FDLL4151	FDLL4151	
FDLL4152	FDLL4152	
FDLL4153	FDLL4153	
FDLL4154	FDLL4154	
FDLL4305	FDLL4305	
FDLL4446	FDLL4446	
FDLL4447	FDLL4447	
FDLL4448	FDLL4448	
FDLL4449	FDLL4449	
FDLL4450	FDLL4450	
FDLL4454	FDLL4454	
FDLL4938	FDLL4938	
FDLL6099	FDLL6099	
FDSO1201		FDSO1201
FDSO1202		FDSO1202
FDSO1203		FDSO1203
FDSO1204		FDSO1204
FDSO1205		FDSO1205
FDSO1401		FDSO1401
FDSO1402		FDSO1402
FDSO1403		FDSO1403
FDSO1404		FDSO1404
FDSO1405		FDSO1405
FDSO1501		FDSO1501
FDSO1502		FDSO1502
FDSO1503		FDSO1503
FDSO1504		FDSO1504
FDSO1505		FDSO1505
FDSO1701		FDSO1701
FDSO1702		FDSO1702
FDSO1703		FDSO1703
FDSO1704		FDSO1704
FDSO1705		FDSO1705

SOT-23 General Purpose and Specialty Diodes

If you need the electrical characteristics for any of the listed industry standards, they are available and guaranteed by four device families. Each of these families are available in five configurations including: single, series, common cathode and common anode. Please see the appropriate data sheet for details.

FDSO1200 Family
1N659
1N916
1N916A
1N916B
1N3064
1N3600
1N4009
1N4149
1N4150
1N4151
1N4154
1N4305
1N4446
1N4449
1N4450
1N4455
FDH600
FDH666
MMBD2835
MMBD2836
MMBD2837
MMBD2838
MMBD6050
MMBD6100

FDSO1500 Family
1N625
1N626
1N627
1N628
1N629
1N658
1N660
1S920
1S921
1S922
1S923
FDH400
FDH444

FDSO1500 Family
1N456
1N456A
1N457
1N457A
1N458
1N458A
1N459
1N459A
1N461A
1N462A
1N463A
1N482B
1N483B
1N484B
1N485B
166099
FDH300
FDH333

FDSO1700 Family
1N4244
1N4376
FDH700

National Semiconductor

Diode Selection Guide

Computer Diodes (By Increasing t_{rr})

Glass Package

Device No.	t_{rr} ns Max	V_{RRM} V Min	I_R nA Max	@	V_R V	V_F V Max	@	I_F mA	C pF Max	Package No.
FD700	0.70	30	50		20	1.1		50	1.0	DO-7
1N4376	0.75	20	100		10	1.1		50	1.0	DO-7
1N4244	0.75	20	100		10	1.0		20	0.8	DO-7
BAY82	0.75	15	100		12	1.0		20	1.3	DO-7
FD777	0.75	15	100		8.0	1.0		20	1.3	DO-7
1N5282	2.0	80	100		55	1.3		500	2.5	DO-35
1N4153	2.0	75	50		50	0.88		20	4.0	DO-35
1N4151	2.0	75	50		50	1.0		50	4.0	DO-35
1N4305	2.0	75	100		50	0.85		10	2.0	DO-35
BAY71	2.0	50	100		35	1.0		20	2.0	DO-35
1N4152	2.0	40	50		30	0.88		20	4.0	DO-35
1N4154	2.0	35	100		25	1.0		30	4.0	DO-35
1N914	4.0	100	25		20	1.0		10	4.0	DO-35
1N914A	4.0	100	25		20	1.0		20	4.0	DO-35
1N914B	4.0	100	25		20	1.0		100	4.0	DO-35
1N916	4.0	100	25		20	1.0		10	2.0	DO-35
1N916A	4.0	100	25		20	1.0		20	2.0	DO-35
1N916B	4.0	100	25		20	1.0		30	2.0	DO-35
1N4148	4.0	100	25		20	1.0		10	4.0	DO-35
1N4149	4.0	100	25		20	1.0		10	2.0	DO-35
1N4446	4.0	100	25		20	1.0		20	4.0	DO-35
1N4447	4.0	100	25		20	1.0		20	4.0	DO-35
1N4448	4.0	100	25		20	1.0		100	2.0	DO-35
1N4449	4.0	100	25		20	1.0		30	2.0	DO-35
1N3600	4.0	75	100		50	1.0		200	2.5	DO-35
FDH600	4.0	75	100		50	1.0		200	2.5	DO-35
1N3064	4.0	75	100		50	1.0		10	2.0	DO-35
1N4150	4.0	75	100		50	1.0		200	2.5	DO-35
1N4454	4.0	75	100		50	1.0		10	2.0	DO-35
BAX13	4.0	50	200		50	1.0		20	3.0	DO-35

Computer Diodes (By Increasing t_{rr}) (Continued)

Glass Package

Device No.	t_{rr} ns Max	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	Package No.
BAY74	4.0	50	100	35	1.1	300	3.0	DO-35
FDH900	4.0	45	500	40	1.1	100	3.0	DO-35
FDH666	4.0	40	100	25	1.0	100	3.5	DO-35
1N4450	4.0	40	50	30	1.0	200	4.0	DO-35
1N4009	4.0	35	100	25	1.0	30	4.0	DO-35
1N625	4.0	30	1000	20	1.5	4.0		DO-35
FDH999	5.0	35	1000	25	1.0	10	5.0	DO-35
FDH1000	100	75	50	20	1.0	500	5.0	DO-35

Leadless Glass Package

Device No.	t_{rr} ns Max	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	Package No.
FDLL4153	2.0	75	50	50	0.88	20	4.0	LL-34
FDLL4151	2.0	75	50	50	1.0	50	4.0	LL-34
FDLL4305	2.0	75	100	50	0.85	10	2.0	LL-34
FDLL4152	2.0	40	50	30	0.88	20	4.0	LL-34
FDLL4154	2.0	35	100	25	1.0	30	4.0	LL-34
FDLL914	4.0	100	25	20	1.0	10	4.0	LL-34
FDLL914A	4.0	100	25	20	1.0	20	4.0	LL-34
FDLL914B	4.0	100	25	20	1.0	100	4.0	LL-34
FDLL916	4.0	100	25	20	1.0	10	2.0	LL-34
FDLL916A	4.0	100	25	20	1.0	20	2.0	LL-34
FDLL916B	4.0	100	25	20	1.0	30	2.0	LL-34
FDLL4148	4.0	100	25	20	1.0	10	4.0	LL-34
FDLL4149	4.0	100	25	20	1.0	10	2.0	LL-34
FDLL4446	4.0	100	25	20	1.0	20	4.0	LL-34
FDLL4447	4.0	100	25	20	1.0	20	4.0	LL-34
FDLL4448	4.0	100	25	20	1.0	100	2.0	LL-34
FDLL4449	4.0	100	25	20	1.0	30	2.0	LL-34
FDLL3600	4.0	75	100	50	1.0	200	2.5	LL-34
FDLL600	4.0	75	100	50	1.0	200	2.5	LL-34
FDLL3064	4.0	75	100	50	1.0	10	2.0	LL-34
FDLL4150	4.0	75	100	50	1.0	200	2.5	LL-34
FDLL4454	4.0	75	100	50	1.0	10	2.0	LL-34
FDLL666	4.0	40	100	25	1.0	100	3.5	LL-34
FDLL4450	4.0	40	50	30	1.0	200	4.0	LL-34
FDLL4009	4.0	35	100	25	1.0	30	4.0	LL-34
FDLL625	50	30	1000	20	1.5	4.0		LL-34

Low Leakage Diodes (By Decreasing V_{RRM})

Glass Package

Device No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	Package No.
1N485B	200	25	180	1.0	100		DO-35
1N459	200	25	175	1.0	3.0		DO-35
1N459A	200	25	175	1.0	100		DO-35
FDH300	150	1.0	125	1.0	200	6.0	DO-35
1N3595	150	1.0	125	1.0	200	8.0	DO-35
1N6099	150	1.0	125	1.0	200	8.0	DO-35
FDH333	150	3.0	125	1.05	200	6.0	DO-35
1N458A	150	5.0	125	1.0	100		DO-35
1N484B	150	25	130	1.0	100		DO-35
1N458	150	25	125	1.0	7.0	6.0	DO-35
BAY73	125	5.0	100	1.0	200	8.0	DO-35
1N483B	80	25	70	1.0	100		DO-35
1N457	70	25	60	1.0	20	8.0	DO-35
1N457A	70	25	60	1.0	100		DO-35
1N482B	40	25	36	1.0	100		DO-35
FJT1100	30	0.001	5.0	1.05	10	1.5	DO-7
1N456A	30	25	25	1.0	100		DO-35
1N456	30	25	25	1.0	40	10	DO-35

Leadless Glass Package

Device No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	Package No.
FDLL459	200	25	175	1.0	3.0		LL-34
FDLL459A	200	25	175	1.0	100		LL-34
FDLL485B	200	25	180	1.0	100		LL-34
FDLL300	150	1.0	125	1.0	200	6.0	LL-34
FDLL3595	150	1.0	125	1.0	200	8.0	LL-34
FDLL6099	150	1.0	125	1.0	200	8.0	LL-34
FDLL333	150	3.0	125	1.05	200	6.0	LL-34
FDLL458A	150	5.0	125	1.0	100		LL-34
FDLL484B	150	25	130	1.0	100		LL-34
FDLL458	150	25	125	1.0	7.0	6.0	LL-34
FDLL483B	80	25	70	1.0	100		LL-34
FDLL457	70	25	60	1.0	20	8.0	LL-34
FDLL457A	70	25	60	1.0	100		LL-34
FDLL482B	40	25	36	1.0	100		LL-34
FDLL456A	30	25	25	1.0	100		LL-34
FDLL456	30	25	25	1.0	40	10	LL-34

High Voltage Diodes (By Decreasing V_{RRM})

Glass Package

Device No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Package No.
1N486B	250	50	225	1.0	100			DO-35
BAV21	250	100	200	1.0	100		50	DO-35
1N661	240	10000	200	1.0	6.0		300	DO-35
FDH400	200	100	150	1.0	200	2.0	50	DO-35
1N3070	200	100	175	1.0	100	5.0	50	DO-35
1N4938	200	100	175	1.0	100	5.0	50	DO-35
BAV20	200	100	150	1.0	100		50	DO-35
1N629	200	1000	175	1.5	4.0		1000	DO-35
FDH444	150	50	100	1.1	200	2.5	60	DO-35
1N628	150	1000	125	1.5	4.0		1000	DO-35
BAY72	125	100	100	1.0	100	5.0	50	DO-35
BAY80	120	100	120	1.0	150	6.0		DO-35
BAV19	120	100	100	1.0	100		50	DO-35
1N658	120	50	50	1.0	100		300	DO-35
1N660	120	5000	100	1.0	6.0		300	DO-35
1N627	100	1000	75	1.5	4.0		1000	DO-35
1N626	50	1000	35	1.5	4.0		1000	DO-35

Leadless Glass Package

Device No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Package No.
FDLL486B	250	50	225	1.0	100			LL-34
FDLL400	200	100	150	1.0	200	2.0	50	LL-34
FDLL3070	200	100	175	1.0	100	5.0	50	LL-34
FDLL629	200	1000	175	1.5	4.0		1000	LL-34
FDLL444	150	50	100	1.1	200	2.5	60	LL-34
FDLL628	150	1000	125	1.5	4.0		1000	LL-34
FDLL658	120	50	50	1.0	100		300	LL-34
FDLL660	120	5000	100	1.0	6.0		300	LL-34
FDLL627	100	1000	75	1.5	4.0		1000	LL-34
FDLL626	50	1000	35	1.5	4.0		1000	LL-34

General Purpose Diodes (By Decreasing V_{RRM})

Glass Package

Device No.	V_{RRM} V Min	I_R nA Max	@	V_R V	V_F V Max	@	I_F mA	C pF Max	t_{rr} ns Max	Package No.
1N661	240	10000		200	1.0		6.0		300	DO-35
1S923	200	100		200	1.2		200			DO-35
1N463A	200	500		175	1.0		100			DO-35
1S922	150	100		150	1.2		200			DO-35
BAX16	150	100		150	1.0		1.0	10	120	DO-35
1N660	120	5000		100	1.0		6.0			DO-35
1S921	100	100		100	1.2		200			DO-35
BA128	75	100		50	1.0		50	5.0		DO-35
1N462A	70	500		60	1.0		100			DO-35
BAV18	60	100		50	1.0		100		50	DO-35
1N659	60	5000		50	1.0		6.0			DO-35
1S920	50	100		50	1.2		200			DO-35
BA218	50	50		25	1.0		10	5.0		DO-35
1S44	50	50		10	1.0		10	4.0	8	DO-35
FDH900	45	500		40	1.0		100	3.0	4.0	DO-35
FDH999	35	1000		25	1.0		10	5.0	5.0	DO-35
1N461A	30	500		25	1.0		100	10		DO-35
BA217	30	50		10	1.0		10	5.0		DO-35
BA130	30	100		25	1.0		10	2.0		DO-35
BAV17	25	100		20	1.0		100		50	DO-35

Leadless Glass Package

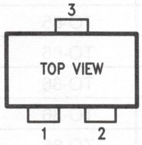
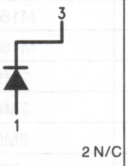
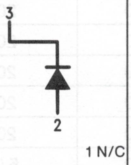
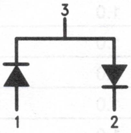
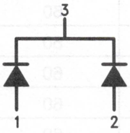
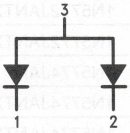
Device No.	V_{RRM} V Min	I_R nA Max	@	V_R V	V_F V Max	@	I_F mA	C pF Max	Package No.
FDLL661	240	10000		200	1.0		6.0		LL-34
FDLL923	200	100		200	1.2		200		LL-34
FDLL463A	200	500		175	1.0		100		LL-34
FDLL922	150	100		150	1.2		200		LL-34
FDLL921	100	100		100	1.2		200		LL-34
FDLL462A	70	500		60	1.0		100		LL-34
FDLL659	60	5000		50	1.0		6.0		LL-34
FDLL920	50	100		50	1.2		200		LL-34
FDLL461A	30	500		25	1.0		100	10	LL-34

Surface Mount Diodes

Plastic Package

Device No.	Description	t_{rr} ns Max	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	Configuration	Package No.
FDSO 1200 FAMILY										
FDSO1201	Single	4.0	75	100	50	1.1	200	2.0	1	TO-236
FDSO1202	Single	4.0	75	100	50	1.1	200	2.0	2	TO-236
FDSO1203	Series	4.0	75	100	50	1.1	200	2.0	3	TO-236
FDSO1204	Common Cathode	4.0	75	100	50	1.1	200	2.0	4	TO-236
FDSO1205	Common Anode	4.0	75	100	50	1.1	200	2.0	5	TO-236
FDSO 1400 FAMILY										
FDSO1401	Single	50	200	100	175	1.0	100	2.0	1	TO-236
FDSO1402	Single	50	200	100	175	1.0	100	2.0	2	TO-236
FDSO1403	Series	50	200	100	175	1.0	100	2.0	3	TO-236
FDSO1404	Common Cathode	50	200	100	175	1.0	100	2.0	4	TO-236
FDSO1405	Common Anode	50	200	100	175	1.0	100	2.0	5	TO-236
FDSO 1500 FAMILY										
FDSO1501	Single		150	1.0	125	1.0	200	4.0	1	TO-236
FDSO1502	Single		150	1.0	125	1.0	200	4.0	2	TO-236
FDSO1503	Series		150	1.0	125	1.0	200	4.0	3	TO-236
FDSO1504	Common Cathode		150	1.0	125	1.0	200	4.0	4	TO-236
FDSO1505	Common Anode		150	1.0	125	1.0	200	4.0	5	TO-236
FSDO 1700 FAMILY										
FDSO914	Single	4.0	100	25	20	1.0	10	4.0	1	TO-236
FDSO1701	Single	0.7	30	50	20	1.1	50	1.0	1	TO-236
FDSO1702	Single	0.7	30	50	20	1.1	50	1.0	2	TO-236
FDSO1703	Series	0.7	30	50	20	1.1	50	1.0	3	TO-236
FDSO1704	Common Cathode	0.7	30	50	20	1.1	50	1.0	4	TO-236
FDSO1705	Common Anode	0.7	30	50	20	1.1	50	1.0	5	TO-236
FDSO3070	Single	50	200	100	175	1.0	100	5.0	1	TO-236
FDSO3595	Single		150	1.0	125	1.0	200	8.0	1	TO-236
FDSO4148	Single	4.0	100	25	20	1.0	10	4.0	1	TO-236
FDSO4448	Single	4.0	100	25	20	1.0	100	2.0	1	TO-236
BAS16	Single	6.0	75	1000	75	1.1	50	2.0	1	TO-236
BAS19	Single	50	100	100	100	1.0	100	5.0	1	TO-236
BAS20	Single	50	150	100	150	1.0	100	5.0	1	TO-236
BAS21	Single	50	200	100	200	1.0	100	5.0	1	TO-236
BAS29	Single	50	90			0.84	50		1	TO-236
BAS31	Series	50	90			0.84	50		3	TO-236
BAS35	Common Anode	50	90			0.84	50		5	TO-236
BAV70	Common Cathode	6.0	70	5000	70	1.1	50	1.5	4	TO-236
BAV74	Common Cathode	4.0	50	100	50	0.84	50	2.0	4	TO-236
BAV99	Series	6.0	70	2500	70	1.1	50	1.5	3	TO-236
BAW56	Common Anode	6.0	70	2500	70	1.1	50	2.5	5	TO-236

Surface Mount Diode Configurations

Configuration	**1**	**2**	**3**	**4**	**5**
Pin Out Diagram  TL/G/10012-6	 TL/G/10012-7	 TL/G/10012-8	 TL/G/10012-9	 TL/G/10012-10	 TL/G/10012-11

Diode Arrays by V_{RRM} and t_{rr}

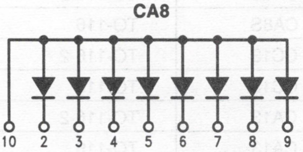
Device No.	V_{RRM} (V)	V_{FM} (V) @	I_F (mA)	t_{rr} (ns) Max	Configuration	Package No.
FSA2002M	60	1.0	100	10	CC8	TO-85
FSA2003M	60	1.0	100	10	CA8	TO-85
FSA2500M	60	1.0	100	10	M16	TO-85
FSA2501M	60	1.0	100	10	M16S	TO-116-2
FSA2501P	60	1.0	100	10	M16S	TO-116
FSA2502M	60	1.0	100	10	M16M	TO-96
FSA2503M	60	1.0	100	10	2M8	TO-116-2
FSA2503P	60	1.0	100	10	2M8	TO-116
FSA2504M	60	1.0	100	10	2M8	TO-86
FSA2508P	60	1.3	500	10	2M8	9B
FSA2509M	60	1.3	500	10	2M8	TO-116-2
FSA2509P	60	1.3	500	10	2M8	TO-116
FSA2510M	60	1.3	500	10	M16S	TO-116-2
FSA2510P	60	1.3	500	10	M16S	TO-116
FSA2563M	60	1.3	500	10	CC8S	TO-116-2
FSA2563P	60	1.3	500	10	CC8S	TO-116
FSA2564M	60	1.3	500	10	CA8S	TO-116-2
FSA2564P	60	1.3	500	10	CA8S	TO-116
FSA2565M	60	1.3	500	10	CC13	TO-116-2
FSA2565P	60	1.3	500	10	CC13	TO-116
FSA2566M	60	1.3	500	10	CA13	TO-116-2
FSA2566P	60	1.3	500	10	CA13	TO-116
1N6496	60	1.5	500	10	2M16	20 Lead Cerpak
1N5768JAN	60	1.0	100	20	CC8	TO-85
1N5768JANTX	60	1.0	100	20	CC8	TO-85
1N5768JANTXV	60	1.0	100	20	CC8	TO-85
1N5770JAN	60	1.0	100	20	CA8	TO-85
1N5770JANTX	60	1.0	100	20	CA8	TO-85
1N5770JANTXV	60	1.0	100	20	CA8	TO-85

Diode Arrays by V_{RRM} and t_{rr} (Continued)

Device No.	V_{RRM} (V)	V_{FM} (V)	@ I_F (mA)	t_{rr} (ns) Max	Configuration	Package No.
1N5772JAN	60	1.0	100	20	M16N	TO-85
1N5772JANTX	60	1.0	100	20	M16N	TO-85
1N5772JANTXV	60	1.0	100	20	M16N	TO-85
1N5774JAN	60	1.0	100	20	2M8	TO-86
1N5774JANTX	60	1.0	100	20	2M8	TO-86
1N5774JANTXV	60	1.0	100	20	2M8	TO-86
1N6100	75	1.0	100	5.0	S7	TO-86
1N6100JAN	75	1.0	100	5.0	S7	TO-86
1N6100JANTX	75	1.0	100	5.0	S7	TO-86
1N6100JANTXV	75	1.0	100	5.0	S7	TO-86
1N6101	75	1.0	100	5.0	S8	6B
1N6101JAN	75	1.0	100	5.0	S8	6B
1N6101JANTX	75	1.0	100	5.0	S8	6B
1N6101JANTXV	75	1.0	100	5.0	S8	6B
FSA2719M	75	1.0	10	6.0	S8	6B
FSA2719P	75	1.0	10	6.0	S8	9B
FSA2720M	75	1.0	10	6.0	S7	TO-116-2
FSA2720P	75	1.0	10	6.0	S7	TO-116
FSA2721M	75	1.0	10	6.0	S7	TO-86
FSA2619M	100	1.0	10	5.0	S8	6B
FSA2619P	100	1.0	10	5.0	S8	9B
FSA2620M	100	1.0	10	5.0	S7	TO-116-2
FSA2620P	100	1.0	10	5.0	S7	TO-116
FSA2621M	100	1.0	10	5.0	S7	TO-86
FSA2621P	100	1.0	10	5.0	S7	TO-116

Diode Array Configurations

CA8



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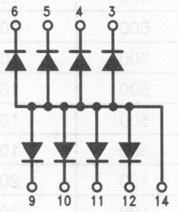
CA8S



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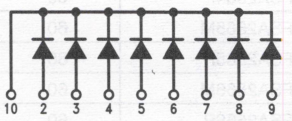
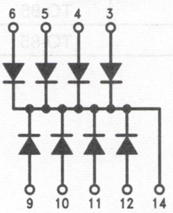


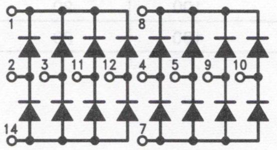
TL/G/10012-2

CC8S



TL/G/10012-14

2M8



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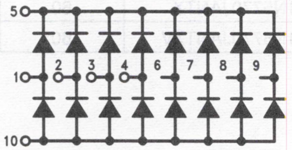
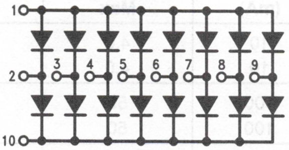
M16M



TL/G/10012-13

Diode Array Configurations (Continued)

M16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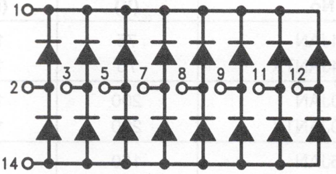
TL/G/10012-3

M16S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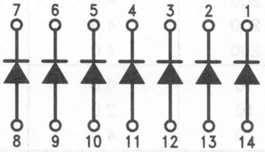
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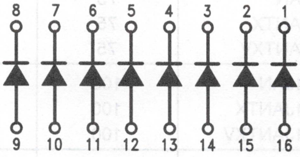
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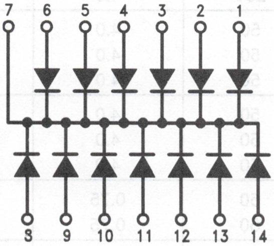
CC13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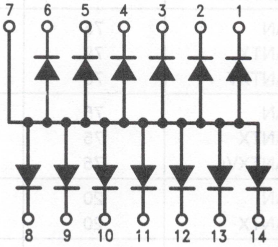
TL/G/10012-17

CA13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TL/G/10012-19

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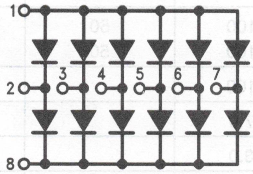

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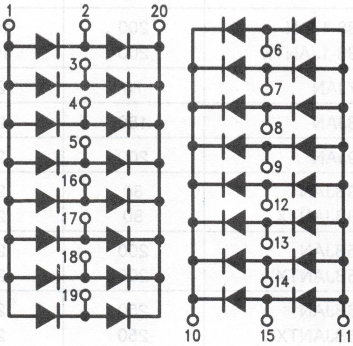
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TL/G/10012-20

Military Diode Products in Numerical Order by Part Number

Device No.	V_{RRM} (V)	I_{RRM} (nA)	V_{FM} (V) @	I_F (mA)	t_{rr} (ns) Max	Package No.
1N3064JAN	75	100	1.0	10	4.0	DO-7
1N3064JANTX	75	100	1.0	10	4.0	DO-7
1N3070JAN	200	100	1.0	100	50	DO-35
1N3070JANTX	200	100	1.0	100	50	DO-35
1N3595JAN	150	1.0	1.0	200	3000	DO-7
1N3595JANTX	150	1.0	1.0	200	3000	DO-7
1N3595JANTXV	150	1.0	1.0	200	3000	DO-7
1N3600JAN	75	100	1.0	200	4.0	DO-7
1N3600JANTX	75	100	1.0	200	4.0	DO-7
1N3600JANTXV	75	100	1.0	200	4.0	DO-7
1N4148-1JAN	100	25	1.0	10	4.0	DO-35
1N4148-1JANTX	100	25	1.0	10	2.0	DO-35
1N4148-1JANTXV	100	25	1.0	10	4.0	DO-35
1N4150-1JAN	75	100	1.0	200	4.0	DO-35
1N4150-1JANTX	75	100	1.0	200	4.0	DO-35
1N4150-1JANTXV	75	100	1.0	200	4.0	DO-35
1N4306JAN	75	50	1.0	50	4.0	DO-7
1N4306JANTX	75	50	1.0	50	4.0	DO-7
1N4306JANTXV	75	50	1.0	50	4.0	DO-7
1N4307JAN	75	50	1.0	50	4.0	DO-7
1N4307JANTX	75	50	1.0	50	4.0	DO-7
1N4307JANTXV	75	50	1.0	50	4.0	DO-7
1N4376JAN	20	100	1.1	50	0.75	DO-7
1N4376JANTX	20	100	1.1	50	0.75	DO-7
1N4454-1JAN	75	100	1.0	10	4.0	DO-35
1N4454-1JANTX	75	100	1.0	10	4.0	DO-35
1N4454-1JANTXV	75	100	1.0	10	4.0	DO-35
1N4938-1JAN	200	100	1.0	100	50	DO-35
1N4938-1JANTX	200	100	1.0	100	50	DO-35
1N457JAN	70	25	1.0	100		DO-35
1N458JAN	150	25	1.0	7.0		DO-35
1N459JAN	200	25	1.0	3.0		DO-35
1N483BJAN	80	25	1.0	100		DO-35
1N483BJANTX	80	25	1.0	100		DO-35
1N485BJAN	200	25	1.0	100		DO-35
1N485BJANTX	200	25	1.0	100		DO-35
1N486BJAN	250	25	1.0	100		DO-35
1N486BJANTX	250	25	1.0	100		DO-35
1N914JAN	100	25	1.0	10	4.0	DO-35
1N914JANTX	100	25	1.0	10	4.0	DO-35

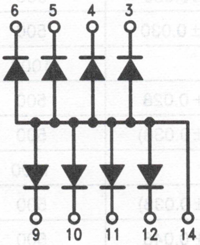
Surface Mount Monolithic Diode Arrays

Plastic Packages

Device No.	V_{RRM} V Min	V_F V Max	@	I_F mA	ΔV_F mV Max	t_{rr} ns Max	Configuration	Package No.
FASO2501	60	1.0		100	15	10	M16S	14-SOIC
FASO2503	60	1.0		100	15	10	2M8	14-SOIC
FASO2509	60	1.3		500	15	10	2M8	14-SOIC
FASO2510	60	1.3		500	15	10	M16S	14-SOIC
FASO2563	60	1.3		500	15	10	CC8S	14-SOIC
FASO2564	60	1.3		500	15	10	CA8S	14-SOIC
FASO2619	100	1.0		10	15	5.0	S8	16-SOIC
FASO2620	100	1.0		10	15	5.0	S7	14-SOIC
FASO2719	75	1.0		10	15	6.0	S8	16-SOIC
FASO2720	75	1.0		10	15	6.0	S7	14-SOIC
FASO5774	60	1.0		100	15	20	2M8	14-SOIC
FASO6101	75	1.0		100		5.0	S7	14-SOIC

Surface Mount Monolithic Diode Array Configurations

CA8S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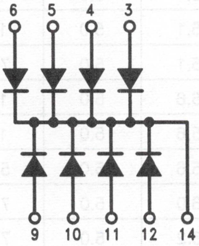
TL/G/10012-21

CC8S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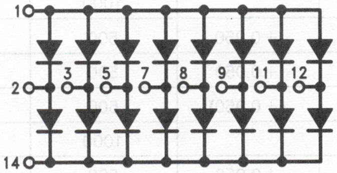
TL/G/10012-22

M16S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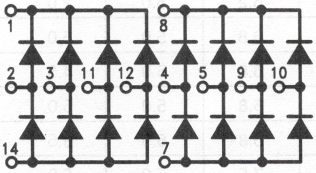
TL/G/10012-23

2M8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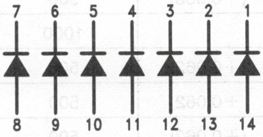
TL/G/10012-24

S7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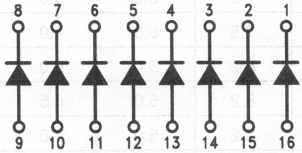
TL/G/10012-25

S8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TL/G/10012-26

Zener Diodes (By Increasing V_Z)

Glass Package

Device No.	V_Z V Nom	Tol.* $\pm V_Z$ %	Z_Z Ω Max	@ I_Z mA	I_R µA Max	@ V_R V	T.C. %/°C Typ (Max)	P_D mW $T_A = 25°C$	Package No.
1N746A	3.3	5.0	28	20	10	1.0	−0.070	500	DO-35
1N5226B	3.3	5.0	28	20	25	1.0	(−0.070)	500	DO-35
1N4728A	3.3	5.0	10	76	100	1.0		1000	DO-41
1N747A	3.6	5.0	24	20	10	1.0	−0.65	500	DO-35
1N5227B	3.6	5.0	24	20	15	1.0	(−0.065)	500	DO-35
1N4729A	3.6	5.0	10	69	100	1.0		1000	DO-41
1N748A	3.9	5.0	23	20	10	1.0	−0.60	500	DO-35
1N5228B	3.9	5.0	23	20	10	1.0	(−0.60)	500	DO-35
1N4730A	3.9	5.0	9.0	64	50	1.0		1000	DO-41
1N749A	4.3	5.0	22	20	2.0	1.0	(±0.055)	500	DO-35
1N5229B	4.3	5.0	22	20	5.0	1.0	(±0.055)	500	DO-35
1N4731A	4.3	5.0	9.0	58	10	1.0		1000	DO-41
1N750A	4.7	5.0	19	20	2.0	1.0	±0.043	500	DO-35
1N5230B	4.7	5.0	19	20	5.0	2.0	(±0.030)	500	DO-35
1N4732A	4.7	5.0	8.0	53	10	1.0		1000	DO-41
1N751A	5.1	5.0	17	20	1.0	1.0	±0.030	500	DO-35
1N5231B	5.1	5.0	17	20	5.0	2.0	(±0.030	500	DO-35
1N4733A	5.1	5.0	7.0	49	10	1.0		1000	DO-41
1N752A	5.6	5.0	11	20	1.0	1.0	+0.028	500	DO-35
1N5232B	5.6	5.0	11	20	5.0	3.0	(±0.038)	500	DO-35
1N4734A	5.6	5.0	5.0	45	10	2.0		1000	DO-41
1N5233B	6.0	5.0	7.0	20	5.0	3.5	(±0.038)	500	DO-35
1N753A	6.2	5.0	7.0	20	0.1	1.0	+0.045	500	DO-35
1N5234B	6.2	5.0	7.0	20	5.0	4.0	(+0.045)	500	DO-35
1N4735A	6.2	5.0	2.0	41	10	3.0		1000	DO-41
1N754A	6.8	5.0	5.0	20	0.1	1.0	+0.050	500	DO-35
1N957B	6.8	5.0	4.5	18.5	150	5.2	+0.050	500	DO-35
1N5235B	6.8	5.0	5.0	20	3.0	5.0	(+0.050)	500	DO-35
1N4736A	6.8	5.0	3.5	37	10	4.0		1000	DO-41
1N755A	7.5	5.0	6.0	20	0.1	1.0	+0.058	500	DO-35
1N958B	7.5	5.0	5.5	16.5	75	5.7	+0.058	500	DO-35
1N5236B	7.5	5.0	6.0	20	3.0	6.0	(+0.058)	500	DO-35
1N4737A	7.5	5.0	4.0	34	10	5.0		1000	DO-41
1N756A	8.2	5.0	8.0	20	0.1	1.0	+0.062	500	DO-35
1N959B	8.2	5.0	6.5	15	50	6.2	+0.062	500	DO-35
1N5237B	8.2	5.0	8.0	20	3.0	6.5	(+0.062)	500	DO-35
1N4738A	8.2	5.0	4.5	34	10	6.0		1000	DO-41

***Tolerance:** All zener diodes are also available in ±1%, ±2%, ±10% and ±20% tolerances.

Zener Diodes (By Increasing V_Z)

Glass Package (Continued)

Device No.	V_Z V Nom	Tol.* $\pm V_Z$ %	Z_Z Ω Max @	I_Z mA	I_R µA Max @	V_R V	T.C. %/°C Typ (Max)	P_D mW $T_A = 25°C$	Package No.
1N5238B	8.7	5.0	8.0	20	3.0	6.5	(+0.065)	500	DO-35
1N757A	9.1	5.0	10	20	0.1	1.0	+0.068	500	DO-35
1N960B	9.1	5.0	7.5	14	25	6.9	+0.068	500	DO-35
1N5239B	9.1	5.0	10	20	3.0	7.0	(+0.068)	500	DO-35
1N4739A	9.1	5.0	5.0	8	10	7.0		1000	DO-41
1N758A	10	5.0	17	20	0.1	1.0	+0.075	500	DO-35
1N961B	10	5.0	8.5	12.5	10	7.6	+0.072	500	DO-35
1N5240B	10	5.0	17	20	3.0	8.0	(+0.075)	500	DO-35
1N4740A	10	5.0	7.0	25	10	7.6		1000	DO-41
1N962B	11	5.0	9.5	11.5	5.0	8.4	+0.073	500	DO-35
1N5241B	11	5.0	22	20	2.0	8.4	(+0.076)	500	DO-35
1N4741A	11	5.0	8.0	23	5.0	8.4		1000	DO-41
1N759A	12	5.0	30	20	0.1	1.0	+0.077	500	DO-35
1N963B	12	5.0	11.5	10.5	5.0	9.1	+0.076	500	DO-35
1N5242B	12	5.0	30	20	1.0	9.1	(+0.077)	500	DO-35
1N4742A	12	5.0	9.0	21	5.0	9.1		1000	DO-41
1N964B	13	5.0	13	9.5	5.0	9.9	+0.079	500	DO-35
1N5243B	13	5.0	13	9.5	0.5	9.9	(+0.079)	500	DO-35
1N4743A	13	5.0	10	19	5.0	9.9		1000	DO-41
1N5244B	14	5.0	15	9.0	0.1	10	(+0.082)	500	DO-35
1N965B	15	5.0	16	8.5	5.0	11.4	+0.082	500	DO-35
1N5245B	15	5.0	16	8.5	0.1	11	(+0.082)	500	DO-35
1N4744A	15	5.0	14	17	5.0	11.4		1000	DO-41
1N966B	16	5.0	17	7.8	5.0	12.2	+0.083	500	DO-35
1N5246B	16	5.0	17	7.8	0.1	12	+(0.083)	500	DO-35
1N4745A	16	5.0	16	15.5	5.0	12.2		1000	DO-41
1N5247B	17	5.0	19	7.4	0.1	13	(+0.084)	500	DO-35
1N967B	18	5.0	21	7.0	5.0	13.7	+0.085	500	DO-35
1N5248B	18	5.0	21	7.0	0.1	14	(+0.085)	500	DO-35
IN4746A	18	5.0	20	14	5.0	13.7		1000	DO-41
1N5249B	19	5.0	23	6.6	0.1	14	(+0.086)	500	DO-35
1N968B	20	5.0	25	6.2	5.0	15.2	+0.086	500	DO-35
1N5250B	20	5.0	25	6.2	0.1	15	(+0.086)	500	DO-35
1N4747A	20	5.0	22	12.5	5.0	15.2		1000	DO-41
1N969B	22	5.0	29	5.6	5.0	16.7	+0.087	500	DO-35
1N5251B	22	5.0	29	5.6	0.1	17	(+0.087)	500	DO-35
1N4748A	22	5.0	23	11.5	5.0	16.7		1000	DO-41

***Tolerance:** All zener diodes are also available in ±1%, ±2%, ±10% and ±20% tolerances.

Zener Diodes (By Increasing V_Z)

Glass Package (Continued)

Device No.	V_Z V Nom	Tol.* $\pm V_Z$ %	Z_Z Ω Max @	I_Z mA	I_R µA Max @	V_R V	T.C. %/°C Typ (Max)	P_D mW $T_A = 25°C$	Package No.
1N970B	24	5.0	33	5.2	5.0	18.2	+0.088	500	DO-35
1N5252B	24	5.0	33	5.2	0.1	18	(+0.088)	500	DO-35
1N4749A	24	5.0	25	10.5	5.0	18.2		1000	DO-41
1N5253B	25	5.0	5	5.0	0.1	19	(+0.089)	500	DO-35
1N971B	27	5.0	41	4.6	5.0	20.6	+0.090	500	DO-35
1N5254B	27	5.0	41	4.6	0.1	21	(+0.090)	500	DO-35
1N4750A	27	5.0	35	9.5	5.0	20.6		1000	DO-41
1N5255B	28	5.0	44	4.5	0.1	21	(+0.091)	500	DO-35
1N972B	30	5.0	49	4.2	5.0	22.8	+0.091	500	DO-35
1N5256B	30	5.0	49	4.2	0.1	23	(+0.091)	500	DO-35
1N4751B	30	5.0	40	8.5	5.0	22.8		1000	DO-41
1N973B	33	5.0	58	3.8	5.0	25.1	+0.092	500	DO-35
1N5257B	33	5.0	58	3.8	0.1	25	(+0.092)	500	DO-35
1N4752A	33	5.0	45	7.5	5.0	25.1		1000	DO-41

***Tolerance:** All zener diodes are also available in ±1%, ±2%, ±10% and ±20% tolerances.

National Semiconductor

Military Qualified Discrete Selection Guide

National Semiconductors' Discrete Product Group offers a complete line of Hi-Reliability devices produced in modern production facilities in Santa Clara, California, South Portland, Maine and Cebu, the Philippines. Although emphasis is placed on designing and built-in quality and reliability, a complete reliability screening program has been established. Many products offered in this data book are available in all of the following Hi-Rel configurations.

- Hi-Rel Wafers and Die
- Military Qualified Diodes & Transistors
- Source Controlled Devices (SCD)
- Custom "Level S" Processing

Hi-Rel Wafers and Die

Refer to the DICE section of this databook for information on WAFER and DIE available in four standard configurations.

Military Qualified Diodes and Transistors

National Semiconductor maintains qualified status for all the devices listed in Table I. Most devices are available in three standard quality levels, JAN, JANTX, and JAN TXV, as defined by MIL-STD-19500.

Custom "Level S" Processing

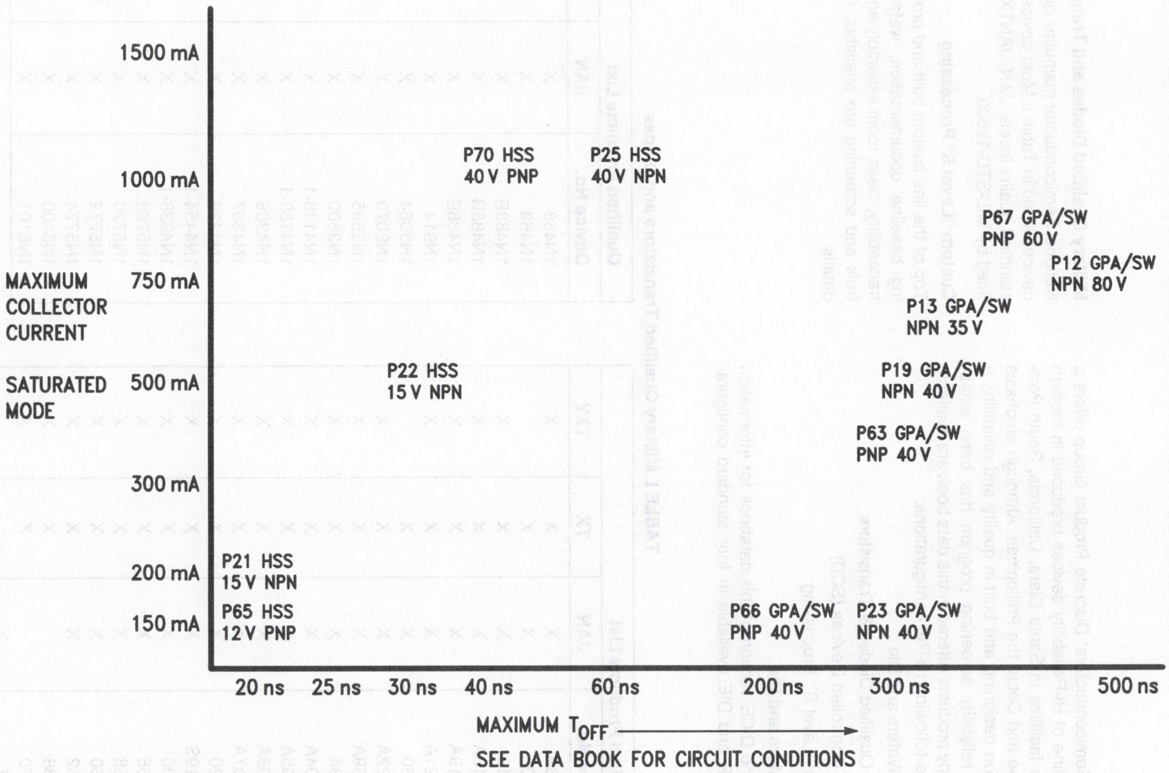
Top of the line custom built and processed devices, requiring baseline documentation, wafer lot acceptance and traceability, clean room assembly and Level S process controls and screening are available. Consult the factory for details.

TABLE I. Military Qualified Transistors and Diodes

Qualified Products List			
Device No.	**JAN**	**TX**	**TXV**
2N718A	X	X	X
2N930	X	X	
2N1613	X	X	X
2N2218A	X	X	X
2N2219A	X	X	X
2N2221A	X	X	X
2N2060	X	X	
2N2222A	X	X	X
2N2369A	X	X	X
2N2484	X	X	X
2N2904A	X	X	X
2N2905A	X	X	X
2N2906A	X	X	X
2N2907A	X	X	X
2N2920	X	X	X
2N3019S	X	X	X
2N3700	X	X	X
2N6756	X	X	X
2N6758	X	X	X
2N6760	X	X	X
2N6762	X	X	X
2N6768		X	X
2N6770		X	X
1N457	X		

Qualified Products List			
Device No.	**JAN**	**TX**	**TXV**
1N458	X		
1N459	X		
1N483B	X	X	X
1N485B	X	X	X
1N486B	X	X	X
1N914	X	X	
1N3064	X	X	
1N3070	X	X	
1N3595	X	X	X
1N3600	X	X	X
1N4148-1	X	X	X
1N4150-1	X	X	X
1N4306	X	X	X
1N4307	X	X	X
1N4376	X	X	
1N4454-1	X	X	X
1N4938-1	X	X	
1N5768	X	X	X
1N5770	X	X	X
1N5772	X	X	X
1N5774	X	X	X
1N6100	X	X	X
1N6101	X	X	X

Transistor Processes for High Speed Switching



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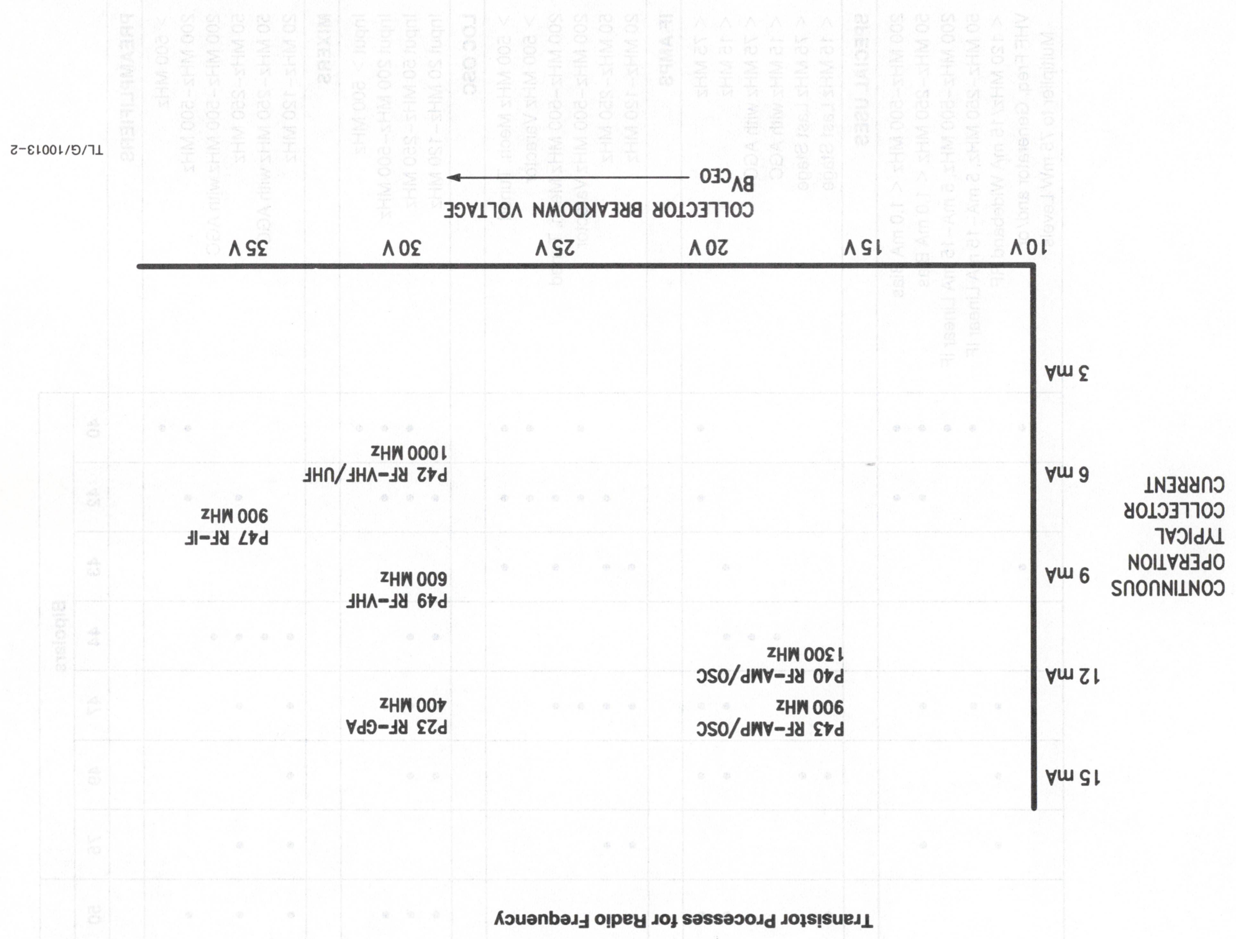
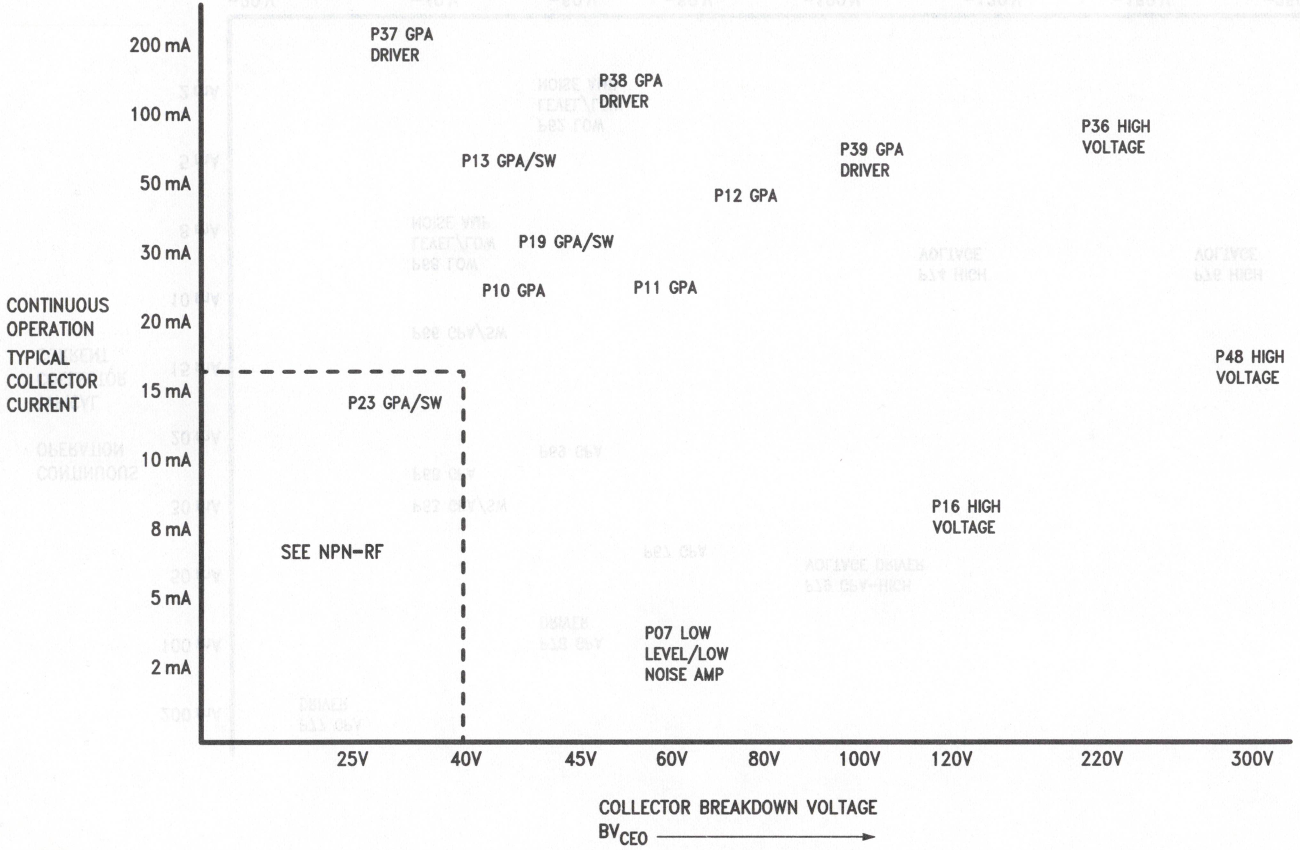
Transistor Processes for Radio Frequency



RF Selection Guide

	Bipolars							JFETs		
	40	42	43	44	47	49	75	50	90	92
PREAMPLIFIERS										
> 500 MHz	•									
200 MHz–500 MHz	•	•						•	•	
200 MHz–500 MHz with AGC				•						
50 MHz–250 MHz		•		•	•		•	•	•	•
50 MHz–250 MHz with AGC				•						
20 MHz–120 MHz				•	•	•	•	•	•	•
MIXERS										
Input > 500 MHz	•									
Input 200 MHz–500 MHz	•	•			•			•	•	
Input 50 MHz–250 MHz	•	•		•	•	•		•	•	
Input 20 MHz–120 MHz		•		•	•	•		•	•	
LOC OSC										
> 500 MHz Mech. Tuned	•	•	•							
> 500 MHz Varactor	•	•								
200 MHz–500 MHz Mech. Tuned		•	•		•					
200 MHz–500 MHz Varactor	•	•			•					
50 MHz–250 MHz		•	•		•		•			
20 MHz–120 MHz			•		•		•			
IF AMPS										
< 75 MHz	•	•			•	•		•	•	
< 15 MHz			•	•	•	•		•		
< 75 MHz with AGC				•						
< 15 MHz with AGC				•						
< 75 MHz Last Stage					•	•				•
< 15 MHz Last Stage						•		•		•
SPECIAL USES										
200 MHz–500 MHz < 1.0 mA Bias	•	•								
50 MHz–250 MHz < 1.0 mA Bias	•	•			•		•			
200 MHz–500 MHz, 5 mA–15 mA Linear IF	•									
50 MHz–250 MHz, 5 mA–15 mA Linear IF	•				•					•
< 120 MHz/15 mA Wideband RF					•	•	•			•
VHF Freq. Generator and/or Multiplier to 75 mW Levels	•		•							

NPN GPA Transistor Processes



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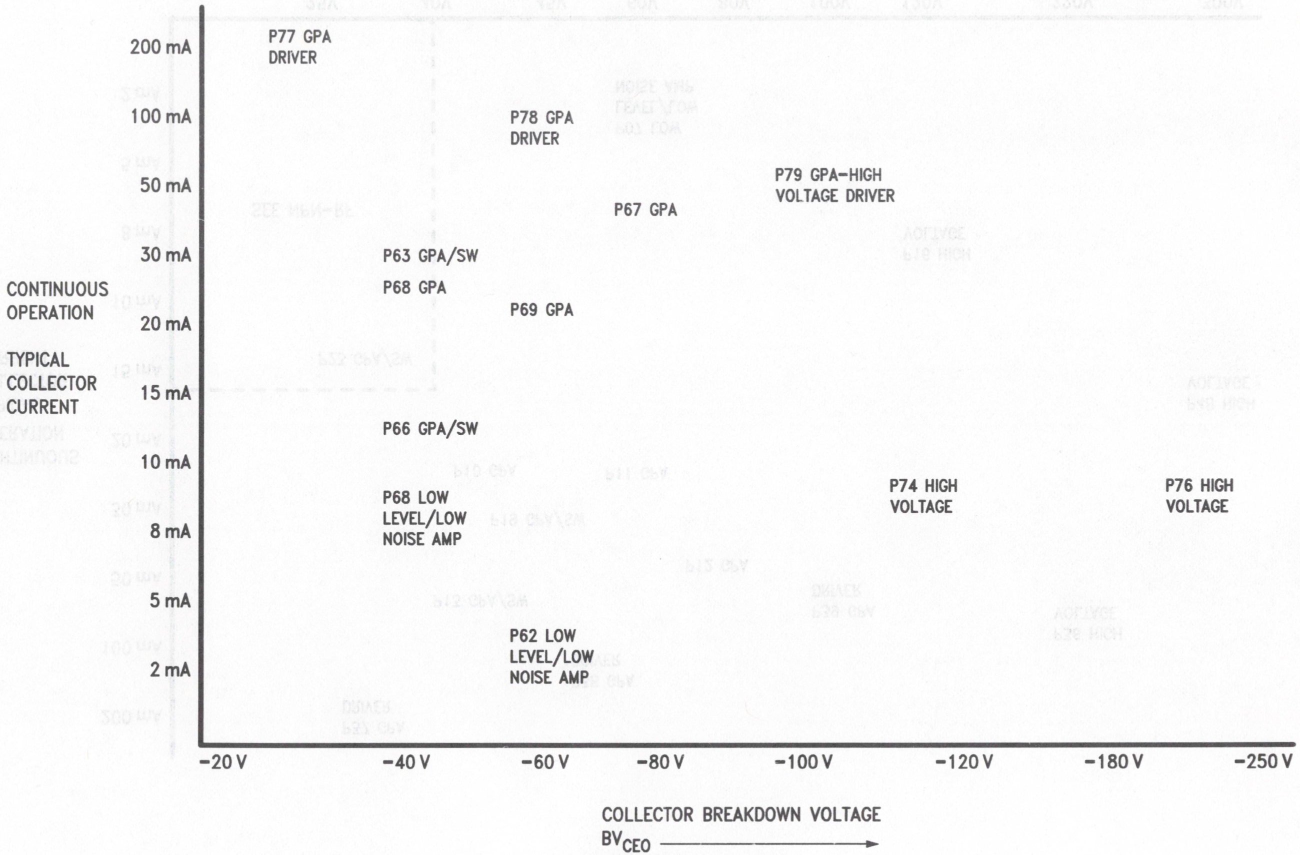
PNP GPA Transistor Processes

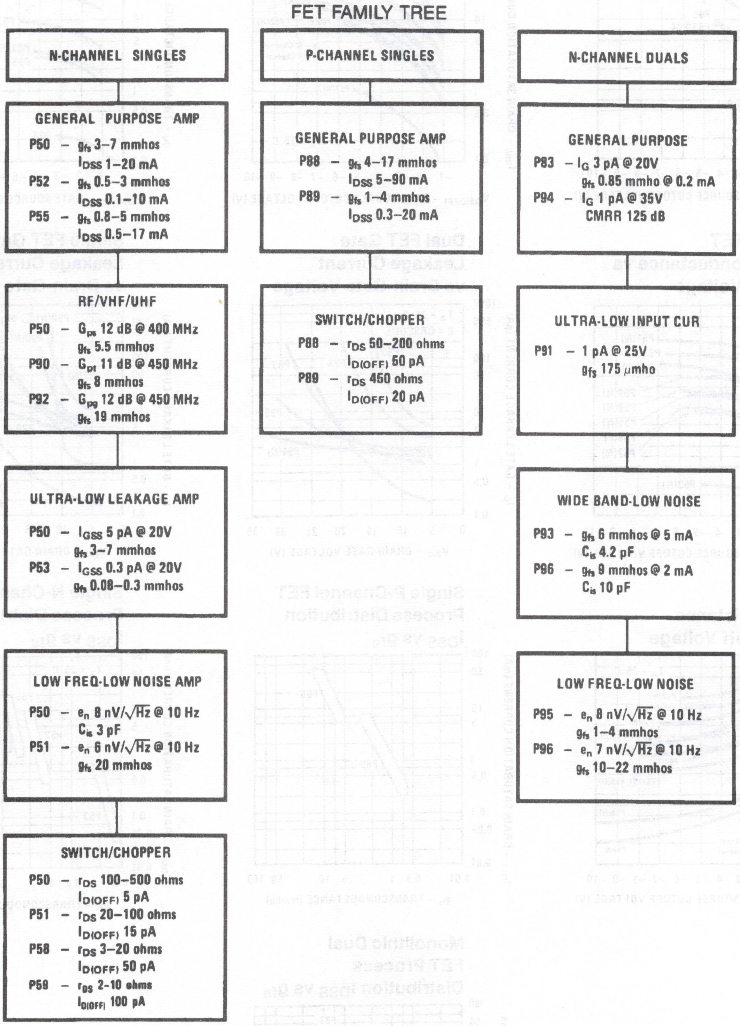


TL/G/10013–5

Choose the Proper FET

National Semiconductor utilizes 17 different FET geometries to cover, without compromise, the full spectrum of applications. Detailed data on each process, along with a list of all part numbers manufactured from each process, is to be found in Section 9.

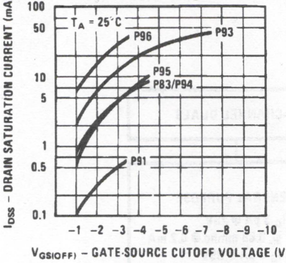
To further simplify the selection procedure, the FET Family Tree is included for quick identification. After narrowing down the process types, it is suggested that the process sheets and specific part number characteristics be consulted.


FET FAMILY TREE
N-CHANNEL SINGLES
GENERAL PURPOSE AMP
P50 – g_{fs} 3–7 mmhos, I_{DSS} 1–20 mA
P52 – g_{fs} 0.5–3 mmhos, I_{DSS} 0.1–10 mA
P55 – g_{fs} 0.8–5 mmhos, I_{DSS} 0.5–17 mA
RF/VHF/UHF
P50 – G_{ps} 12 dB @ 400 MHz, g_{fs} 5.5 mmhos
P90 – G_{pt} 11 dB @ 450 MHz, g_{fs} 8 mmhos
P92 – G_{pg} 12 dB @ 450 MHz, g_{fs} 19 mmhos
ULTRA-LOW LEAKAGE AMP
P50 – I_{GSS} 5 pA @ 20V, g_{fs} 3–7 mmhos
P63 – I_{GSS} 0.3 pA @ 20V, g_{fs} 0.08–0.3 mmhos
LOW FREQ-LOW NOISE AMP
P50 – e_n 8 nV/$\sqrt{Hz}$ @ 10 Hz, C_{is} 3 pF
P51 – e_n 6 nV/$\sqrt{Hz}$ @ 10 Hz, g_{fs} 20 mmhos
SWITCH/CHOPPER
P50 – r_{DS} 100–500 ohms, $I_{D(OFF)}$ 5 pA
P51 – r_{DS} 20–100 ohms, $I_{D(OFF)}$ 15 pA
P58 – r_{DS} 3–20 ohms, $I_{D(OFF)}$ 50 pA
P59 – r_{DS} 2–10 ohms, $I_{D(OFF)}$ 100 pA
P-CHANNEL SINGLES
GENERAL PURPOSE AMP
P88 – g_{fs} 4–17 mmhos, I_{DSS} 5–90 mA
P89 – g_{fs} 1–4 mmhos, I_{DSS} 0.3–20 mA
SWITCH/CHOPPER
P88 – r_{DS} 50–200 ohms, $I_{D(OFF)}$ 50 pA
P89 – r_{DS} 450 ohms, $I_{D(OFF)}$ 20 pA
N-CHANNEL DUALS
GENERAL PURPOSE
P83 – I_G 3 pA @ 20V, g_{fs} 0.85 mmho @ 0.2 mA
P94 – I_G 1 pA @ 35V, CMRR 125 dB
ULTRA-LOW INPUT CUR
P91 – 1 pA @ 25V, g_{fs} 175 μmho
WIDE BAND-LOW NOISE
P93 – g_{fs} 6 mmhos @ 5 mA, C_{is} 4.2 pF
P96 – g_{fs} 9 mmhos @ 2 mA, C_{is} 10 pF
LOW FREQ-LOW NOISE
P95 – e_n 8 nV/$\sqrt{Hz}$ @ 10 Hz, g_{fs} 1–4 mmhos
P96 – e_n 7 nV/$\sqrt{Hz}$ @ 10 Hz, g_{fs} 10–22 mmhos

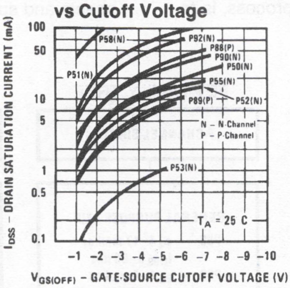
TL/G/10013-6

JFET Process Comparison Curves

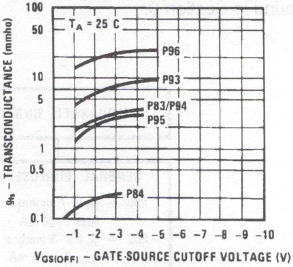
Dual FET Drain Saturation Current vs Cutoff Voltage



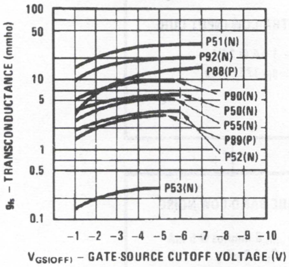
Single FET Drain Saturation Current vs Cutoff Voltage



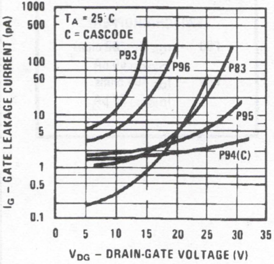
Dual FET Transconductance vs Cutoff Voltage



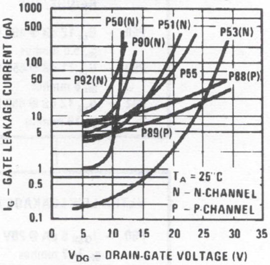
Single FET Transconductance vs Cutoff Voltage



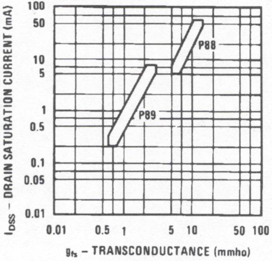
Dual FET Gate Leakage Current vs Drain-Gate Voltage



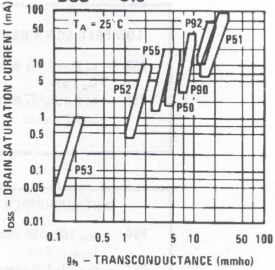
Single FET Gate Leakage Current vs Drain-Gate Voltage



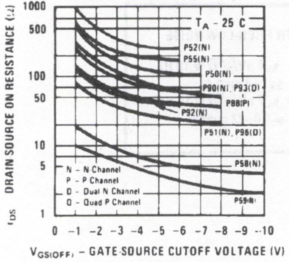
Single P-Channel FET Process Distribution I_{DSS} vs g_{fs}



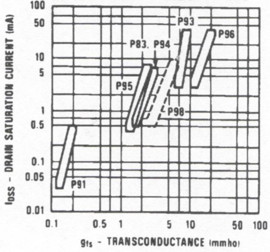
Single N-Channel FET Process Distribution I_{DSS} vs g_{fs}



On Resistance vs Cutoff Voltage



Monolithic Dual FET Process Distribution I_{DSS} vs g_{fs}



TL/G/10013–7

National Semiconductor

JFET Cross Reference Guide

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N2386-5	P	TO-5		2N5462-5	8991	TO-92	2N3365	N	TO-18		2N4340	5202	TO-18
2N2386A	P	TO-5		2N5462-5	8991	TO-92	2N3368	N	TO-18	2N3368		5202	TO-18
2N2497	P	TO-5		2N3329-5	8923	TO-72	2N3369	N	TO-18	2N3369		5202	TO-18
2N2498	P	TO-5		2N3330-5	8923	TO-72	2N3370	N	TO-18	2N3370		5202	TO-18
2N2499	P	TO-5		2N3331-5	8923	TO-72	2N3376	P	TO-72		2N3329	8923	TO-72
2N2500	P	TO-5		2N3332-5	8923	TO-72	2N3378	P	TO-72		2N3330	8923	TO-72
2N2606	P	TO-18		2N5020	8911	TO-18	2N3380	P	TO-72		2N3331	8923	TO-72
2N2607	P	TO-18		2N5020	8911	TO-18	2N3382	P	TO-72		2N5116	8811	TO-72
2N2608	P	TO-18	2N2608		8911	TO-18	2N3384	P	TO-72		2N5115	8811	TO-72
2N2609	P	TO-18	2N2609		8911	TO-18	2N3386	P	TO-72		2N5114	8811	TO-72
2N2843	P	TO-18		2N5020	8911	TO-18	2N3436	N	TO-18		2N4222	5525	TO-72
2N2844	P	TO-18		2N5020	8911	TO-18	2N3437	N	TO-18		2N3968	5525	TO-72
2N3066	N	TO-18		2N4340	5202	TO-18	2N3438	N	TO-18		2N5358	5525	TO-72
2N3067	N	TO-18		2N4338	5202	TO-18	2N3453	N	TO-72		2N4119	5325	TO-72
2N3068	N	TO-18		2N4338	5202	TO-18	2N3454	N	TO-72		2N4117	5325	TO-72
2N3069	N	TO-18	2N3069		5202	TO-18	2N3457	N	TO-72		2N4117	5325	TO-72
2N3070	N	TO-18	2N3071		5202	TO-18	2N3458	N	TO-18	2N3458		5202	TO-18
2N3071	N	TO-18	2N3071		5202	TO-18	2N3459	N	TO-18	2N3459		5202	TO-18
2N3084	N	TO-5		2N4340-5	5202	TO-18	2N3460	N	TO-18	2N3460		5202	TO-18
2N3085	N	TO-18		2N4340	5202	TO-18	2N3578	P	TO-18		2N2608	8911	TO-18
2N3086	N	TO-5		2N4340	5202	TO-18	2N3684	N	TO-72	2N3684		5225	TO-72
2N3087	N	TO-18		2N4340	5202	TO-18	2N3684A	N	TO-72		2N3684	5225	TO-72
2N3088	N	TO-5		2N4339-5	5202	TO-18	2N3685	N	TO-72	2N3685		5225	TO-72
2N3088A	N	TO-5		2N4339-5	5202	TO-18	2N3685A	N	TO-72		2N3685	5225	TO-72
2N3089	N	TO-18		2N4339	5202	TO-18	2N3686	N	TO-72	2N3686		5225	TO-72
2N3089A	N	TO-18		2N4339	5202	TO-18	2N3686A	N	TO-72		2N3686A	5225	TO-72
2N3329	P	TO-72	2N3329		8923	TO-72	2N3687	N	TO-72	2N3687		5225	TO-72
2N3330	P	TO-72	2N3330		8923	TO-72	2N3687A	N	TO-72		2N3687	5225	TO-72
2N3331	P	TO-72	2N3331		8923	TO-72	2N3819	N	TO-92	2N3819		5094	TO-92
2N3332	P	TO-72	2N3332		8923	TO-72	2N3820	P	TO-92	2N3820		8994	TO-92

JFET Cross Reference Guide (Continued)

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N3821	N	TO-72	2N3821		5525	TO-72	2N4118	N	TO-72	2N4118		5352	TO-72
2N3822	N	TO-72	2N3822		5525	TO-72	2N4118A	N	TO-72	2N4118A		5325	TO-72
2N3823	N	TO-72	2N3823		5505	TO-72	2N4119	N	TO-72	2N4119		5325	TO-72
2N3824	N	TO-72	2N3824		5525	TO-72	2N4119A	N	TO-72	2N4119A		5325	TO-72
2N3909	P	TO-72		2N3820	8994	TO-92	2N4139	N	TO-18		2N5363	5525	TO-72
2N3909A	P	TO-72		2N5462	8991	TO-92	2N4220	N	TO-72	2N4220		5525	TO-72
2N3921	N	TO-71		2N3921	8312	TO-71	2N4220A	N	TO-72	2N4220A		5525	TO-72
2N3922	N	TO-71	2N3922		8312	TO-71	2N4221	N	TO-72	2N4221		5525	TO-72
2N3954	N	TO-71	2N3954		8312	TO-71	2N4221A	N	TO-72	2N4221A		5525	TO-72
2N3955	N	TO-71	2N3955		8312	TO-71	2N4222	N	TO-72	2N4222		5225	TO-72
2N3955A	N	TO-71	2N3955A		8312	TO-71	2N4222A	N	TO-72	2N4222A		5225	TO-72
2N3956	N	TO-71	2N3956		8312	TO-71	2N4223	N	TO-72	2N4223		5025	TO-72
2N3957	N	TO-71	2N3957		8312	TO-71	2N4224	N	TO-72	2N4224		5025	TO-72
2N3958	N	TO-71	2N3958		8312	TO-71	2N4302	N	TO-106	PN4302-18		5292	TO-92
2N3966	N	TO-72	2N3966		5029	TO-72	2N4303	N	TO-106	PN4303-18		5292	TO-92
2N3967	N	TO-72	2N3967		5225	TO-72	2N4304	N	TO-106	PN4304-18		5292	TO-92
2N3967A	N	TO-72	2N3967A		5525	TO-72	2N4338	N	TO-18	2N4338		5202	TO-18
2N3968	N	TO-72	2N3968		5525	TO-72	2N4339	N	TO-18	2N4339		5202	TO-18
2N3968A	N	TO-72	2N3968A		5525	TO-72	2N4340	N	TO-18	2N4340		5202	TO-18
2N3969	N	TO-72	2N3969		5525	TO-72	2N4341	N	TO-18	2N4341		5202	TO-18
2N3969A	N	TO-72	2N3969A		5525	TO-72	2N4342	P	TO-106	PN4342-18		8991	TO-92
2N3970	N	TO-18	2N3970		5102	TO-18	2N4360	P	TO-106	PN4360-18		8991	TO-92
2N3971	N	TO-18	2N3971		5102	TO-18	2N4381	P	TO-18	2N4318		8991	TO-92
2N3972	N	TO-18	2N3972		5102	TO-18	2N4382	P	TO-18	2N5115		8811	TO-18
2N3993	P	TO-72		2N5116	8811	TO-72	2N4391	N	TO-18	2N4391		5102	TO-18
2N3993A	P	TO-72		2N5116	8811	TO-72	2N4392	N	TO-18	2N4392		5102	TO-18
2N3994	P	TO-72		2N5116	8811	TO-72	2N4393	N	TO-18	2N4393		5102	TO-18
2N3994A	P	TO-72		2N5116	8811	TO-72	2N4416	N	TO-72	2N4416		5025	TO-72
2N4084	N	TO-71	2N4084		8312	TO-71	2N4416A	N	TO-72	2N4416A		5025	TO-72
2N4085	N	TO-71	2N4085		8312	TO-71	2N4445	N	TO-18		2N5432	5807	TO-52
2N4091	N	TO-18	2N4091		5102	TO-18	2N4446	N	TO-18		2N5433	5807	TO-52
2N4092	N	TO-18	2N4092		5102	TO-18	2N4447	N	TO-18		2N5432	5807	TO-52
2N4093	N	TO-18	2N4093		5102	TO-18	2N4448	N	TO-18		2N5433	5807	TO-52
2N4117	N	TO-72	2N4117		5325	TO-72	2N4856	N	TO-18	2N4856		5102	TO-18
2N4117A	N	TO-72	2N4117A		5325	TO-72	2N4856A	N	TO-18	2N4856A		5102	TO-18

JFET Cross Reference Guide (Continued)

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N4857	N	TO-18	2N4857		5102	TO-18	2N5197	N	TO-71	2N5197		8312	TO-18
2N4857A	N	TO-18	2N4857A		5102	TO-18	2N5198	N	TO-71	2N5198		8312	TO-18
2N4858	N	TO-18	2N4858		5102	TO-18	2N5199	N	TO-71	2N5199		8312	TO-18
2N4858A	N	TO-18	2N4858A		5102	TO-18	2N5245	N	TO-106	2N5245-18		9097	TO-92
2N4859	N	TO-18	2N4859		5102	TO-18	2N5246	N	TO-106	2N5246-18		9097	TO-92
2N4859A	N	TO-18	2N4859A		5102	TO-18	2N5247	N	TO-106	2N5247-18		9097	TO-92
2N4860	N	TO-18	2N4860		5102	TO-18	2N5248	N	TO-92	2N5248		5094	TO-92
2N4860A	N	TO-18	2N4860A		5102	TO-18	2N5358	N	TO-72	2N5358		5525	TO-72
2N4861	N	TO-18	2N4861		5102	TO-18	2N5359	N	TO-72	2N5359		5525	TO-72
2N4861A	N	TO-18	2N4861A		5102	TO-18	2N5360	N	TO-72	2N5360		5525	TO-72
2N4867	N	TO-72		2N4339	5202	TO-18	2N5361	N	TO-72	2N5361		5525	TO-72
2N4868	N	TO-72		2N3459	5202	TO-18	2N5362	N	TO-72	2N5362		5525	TO-72
2N4869	N	TO-72		2N4341	5702	TO-18	2N5363	N	TO-72	2N5363		5525	TO-72
2N4977	N	TO-18		2N5432	5807	TO-52	2N5364	N	TO-72	2N5364		5525	TO-72
2N4978	N	TO-18		2N5433	5807	TO-52	2N5397	N	TO-72	2N5397		9025	TO-72
2N4979	N	TO-18		2N5434	5807	TO-52	2N5398	N	TO-72	2N5398		9025	TO-72
2N5018	P	TO-18	2N5018		8811	TO-18	2N5432	N	TO-18	2N5432		5807	TO-72
2N5019	P	TO-18	2N5019		8811	TO-18	2N5433	N	TO-18	2N5433		5807	TO-72
2N5020	P	TO-18	2N5020		8811	TO-18	2N5434	N	TO-18	2N5434		5807	TO-72
2N5021	P	TO-18	2N5021		8991	TO-92	2N5452	N	TO-71	2N5452		8312	TO-71
2N5033	P	TO-106	PN5033-18		8991	TO-92	2N5453	N	TO-71	2N5453		8312	TO-71
2N5045	N	TO-71	2N5045		8312	TO-71	2N5454	N	TO-71	2N5454		8312	TO-71
2N5046	N	TO-71	2N5046		8312	TO-71	2N5457	N	TO-92	2N5457		5592	TO-92
2N5047	N	TO-71	2N5047		8312	TO-71	2N5458	N	TO-92	2N5458		5592	TO-92
2N5078	N	TO-72	2N5078		5025	TO-72	2N5459	N	TO-92	2N5459		5592	TO-92
2N5103	N	TO-72	2N5103		5025	TO-72	2N5460	P	TO-92	2N5460		8991	TO-92
2N5104	N	TO-72	2N5104		5025	TO-72	2N5461	P	TO-92	2N5461		8991	TO-92
2N5105	N	TO-72	2N5105		5025	TO-72	2N5462	P	TO-92	2N5462		8991	TO-92
2N5114	P	TO-18	2N5114		8811	TO-18	2N5471	P	TO-72		2N5020	8911	TO-18
2N5115	P	TO-18	2N5115		8811	TO-18	2N5472	P	TO-72		2N5020	8911	TO-18
2N5116	P	TO-18	2N5116		8811	TO-18	2N5473	P	TO-72		2N5020	8911	TO-18
2N5158	N	TO-18		2N5433	8807	TO-52	2N5474	P	TO-72		2N5020	8911	TO-18
2N5159	N	TO-18		2N5432	5807	TO-52	2N5475	P	TO-72		2N5020	8911	TO-18
2N5163	N	TO-106	PN5163-18		5072	TO-18	2N5476	P	TO-72		2N5020	8911	TO-18
2N5196	N	TO-71	2N5196		8312	TO-18	2N5484	N	TO-92	2N5484		5092	TO-92

JFET Cross Reference Guide (Continued)

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N5485	N	TO-92	2N5485		5092	TO-92	2N5669	N	TO-92	2N5668		5092	TO-92
2N5486	N	TO-92	2N5486		5092	TO-92	2N5670	N	TO-92	2N5670		5092	TO-92
2N5515	N	TO-71	2N5515		9512	TO-71	2N5717	N	TO-92		PN3686	5292	TO-92
2N5516	N	TO-71	2N5516		9512	TO-71	2N5718	N	TO-92		PN4302	5292	TO-92
2N5517	N	TO-71	2N5517		9512	TO-71	2N5801	N	TO-92		J210	9092	TO-92
2N5518	N	TO-71	2N5518		9512	TO-71	2N5802	N	TO-92		J212	9092	TO-92
2N5519	N	TO-71	2N5519		9512	TO-71	2N5902	N	TO-78	2N5902		8424	TO-78
2N5520	N	TO-71	2N5520		9512	TO-71	2N5903	N	TO-78	2N5903		8424	TO-78
2N5521	N	TO-71	2N5521		9512	TO-71	2N5904	N	TO-78	2N5904		8424	TO-78
2N5522	N	TO-71	2N5522		9512	TO-71	2N5905	N	TO-78	2N5905		8424	TO-78
2N5523	N	TO-71	2N5523		9512	TO-71	2N5906	N	TO-78	2N5906		8424	TO-78
2N5524	N	TO-71	2N5524		9512	TO-71	2N5907	N	TO-78	2N5907		8424	TO-78
2N5545	N	TO-71	2N5545		8312	TO-71	2N5908	N	TO-78	2N5908		8424	TO-78
2N5546	N	TO-71	2N5546		8312	TO-71	2N5909	N	TO-78	2N5908		8424	TO-78
2N5547	N	TO-71	2N5547		8312	TO-71	2N5911	N	TO-78	2N5911		9324	TO-78
2N5549	N	TO-72		2N5397	9025	TO-72	2N5912	N	TO-78	2N5912		9324	TO-78
2N5555	N	TO-92	2N5555		5092	TO-92	2N5949	N	TO-106	2N5949-18		5097	TO-92
2N5556	N	TO-72	2N5556		5025	TO-72	2N5950	N	TO-106	2N5950-18		5097	TO-92
2N5557	N	TO-72	2N5557		5025	TO-72	2N5951	N	TO-106	2N5951-18		5097	TO-92
2N5558	N	TO-72	2N5558		5025	TO-72	2N5952	N	TO-106	2N5952-18		5097	TO-92
2N5561	N	TO-71	2N5561		9812	TO-71	2N5953	N	TO-106	2N5953-18		5097	TO-92
2N5562	N	TO-71	2N5562		9812	TO-71	2N6483	N	TO-71	2N6483		9512	TO-71
2N5563	N	TO-71	2N5563		9812	TO-71	2N6484	N	TO-71	2N6484		9512	TO-71
2N5564	N	TO-71	2N5564		9612	TO-71	2N6485	N	TO-71	2N6485		9512	TO-71
2N5565	N	TO-71	2N5565		9612	TO-71	2SK11	N	TO-72		2N3459	5202	TO-18
2N5566	N	TO-71	2N5566		9612	TO-71	2SK12	N	TO-72		2N4340	5202	TO-18
2N5592	N	TO-72		PN5163-18	5092	TO-92	2SK13	N	TO-72		2N4340	5202	TO-18
2N5593	N	TO-72		PN5163-18	5092	TO-92	2SK15	N	TO-72		2N4340	5202	TO-18
2N5594	N	TO-72		PN5163-18	5092	TO-92	2SK19	N	TO-106		2N5485-18	5092	TO-92
2N5638	N	TO-92	2N5638		5192	TO-92	2SK30	N	TO-92		PN4304	5292	TO-92
2N5639	N	TO-92	2N5639		5192	TO-92	2SK37	N	B-69		2N5484	5092	TO-92
2N5640	N	TO-92	2N5640		5192	TO-92	2SK48	N	TO-72		2N3686	5225	TO-72
2N5653	N	TO-92	2N5653		5192	TO-92	2SK68	N	TO-92		PF5101	5192	TO-92
2N5654	N	TO-92	2N5654		5192	TO-92	3SK22	N	TO-72		2N5078	5025	TO-72
2N5668	N	TO-92	2N5668		5092	TO-92	3SK23	N	TO-72		2N5397	9025	TO-72

JFET Cross Reference Guide (Continued)

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
3SK28	N	TO-72		2N5078	5025	TO-72
A5T3821	N	TO-92	2N3821		5525	TO-72
A5T3822	N	TO-92	2N3822		5525	TO-72
A5T3823	N	TO-92	2N3823		5029	TO-72
A5T3824	N	TO-92	2N3824		5525	TO-72
A5T5460	P	TO-92	2N5460		8991	TO-92
A5T5461	P	TO-92	2N5461		8991	TO-92
A5T5462	P	TO-92	2N5462		8991	TO-92
BC264A	N	TO-92	BC264A		5097	TO-92
BC264B	N	TO-92	BC264B		5097	TO-92
BC264C	N	TO-92	BC264C		5097	TO-92
BC264D	N	TO-92	BC264D		5097	TO-92
BF244A	N	TO-92	BF244A		5094	TO-92
BF244B	N	TO-92	BF244B		5094	TO-92
BF244C	N	TO-92	BF244C		5094	TO-92
BF245A	N	TO-92	BF245A		5097	TO-92
BF245B	N	TO-92	BF245B		5097	TO-92
BF245C	N	TO-92	BF245C		5097	TO-92
BF246A	N	TO-92	BF246A		5194	TO-92
BF246B	N	TO-92	BF246B		5194	TO-92
BF246C	N	TO-92	BF246C		5194	TO-92
BF247A	N	TO-92	BF247A		5197	TO-92
BF247B	N	TO-92	BF247B		5197	TO-92
BF247C	N	TO-92	BF247C		5197	TO-92
BF256A	N	TO-92	BF256A		5097	TO-92
BF256B	N	TO-92	BF256B		5097	TO-92
BF256C	N	TO-92	BF256C		5097	TO-92
BFW10	N	TO-72		2N4224	5025	TO-72
BFW11	N	TO-72		2N5558	5025	TO-72
BFW61	N	TO-72		2N4224	5025	TO-72
BSV78	N	TO-18		2N4856	5102	TO-18
BSV79	N	TO-18		2N4857	5102	TO-18
BSV80	N	TO-18		2N4858	5102	TO-18
E101	N	TO-106	J201-18		5292	TO-92
E102	N	TO-106	J202-18		5292	TO-92

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
E103	N	TO-106	J203-18		5292	TO-92
E106	N	TO-106		J108-18	5892	TO-92
E107	N	TO-106		J108-18	5892	TO-92
E108	N	TO-106	J108-18		5892	TO-92
E109	N	TO-106	J109-18		5892	TO-92
E110	N	TO-106	J110-18		5892	TO-92
E111	N	TO-106	J111-18		5192	TO-92
E112	N	TO-106	J112-18		5192	TO-92
E113	N	TO-106	J113-18		5192	TO-92
E114	N	TO-106	J114-18		9092	TO-92
E174	N	TO-106	J174-18		8894	TO-92
E175	N	TO-106	J175-18		8894	TO-92
E176	N	TO-106	J176-18		8894	TO-92
E177	N	TO-106	J177-18		8894	TO-92
E201	N	TO-106	J201-18		5292	TO-92
E202	N	TO-106	J202-18		5292	TO-92
E203	N	TO-106	J203-18		5292	TO-92
E204	N	TO-106		PN4220-18	5592	TO-92
E210	N	TO-106	J210-18		9092	TO-92
E211	N	TO-106	J211-18		9092	TO-92
E212	N	TO-106	J212-18		9092	TO-92
E230	N	TO-106		PN3821-18	5292	TO-92
E231	N	TO-106		PN3684-18	5292	TO-92
E232	N	TO-106		J203-18	5292	TO-92
E270	P	TO-106	J270-18		8894	TO-92
E271	P	TO-106	J271-18		8894	TO-92
E300	N	TO-106	J300-18		9092	TO-92
E304	N	TO-106	J304-18		5092	TO-92
E305	N	TO-106	J305-18		5092	TO-92
E308	N	TO-106	J308-18		9292	TO-92
E309	N	TO-106	J309-18		9292	TO-92
E310	N	TO-106	J310-18		9292	TO-92
E311	N	TO-106	J309		9292	TO-92
E312	N	TO-106		J310-18	9292	TO-92
E430	N	TO-71		2N5566	9612	TO-71

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Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
ESM4091	N	FO-18	2N4091		5102	TO-18
ESM4093	N	FO-18	2N4091		5102	TO-18
ESM4302	N	FO-18	PN4302-18		5292	TO-92
ESM4303	N	FO-18	PN4303-18		5292	TO-92
ESM4304	N	FO-18	PN4304-18		5292	TO-92
FT0654A	N			2N3824	5525	TO-72
FT0654B	N			2N3824	5525	TO-72
FT0654C	N			2N4221	5202	TO-18
FT3820	P	TO-18	2N3820-18		8994	TO-92
GET5457	N		2N5457		5592	TO-92
GET5458	N		2N5458		5592	TO-92
GET5459	N		2N5459		5592	TO-92
IMF3954	N	TO-71		2N3954	8312	TO-71
IMF3954A	N	TO-71		2N3954A	8312	TO-71
IMF3955	N	TO-71		2N3955	8312	TO-71
IMF3956	N	TO-71		2N3956	8312	TO-71
IMF3957	N	TO-71		2N3957	8312	TO-71
IMF3958	N	TO-71		2N3958	8312	TO-71
IMF6485	N	TO-71		2N6485	9512	TO-71
IT101	P	TO-18		2N5114	8811	TO-18
IT108	N			2N5486	5092	TO-92
ITE3066	N	TO-106		2N4340	5202	TO-18
ITE3067	N	TO-106		2N4338	5202	TO-18
ITE3068	N	TO-106		2N4338	5202	TO-18
ITE4117	N	TO-106	PN4117-18		5392	TO-92
ITE4118	N	TO-106	PN4118-18		5392	TO-92
ITE4119	N	TO-106	PN4119-18		5392	TO-92
ITE4338	N	TO-106		2N4338	5202	TO-18
ITE4339	N	TO-106		2N4339	5202	TO-18
ITE4340	N	TO-106		2N4340	5202	TO-18
ITE4341	N	TO-106		2N4391	5202	TO-18
ITE4391	N	TO-106	PN4391-18		5192	TO-92
ITE4392	N	TO-106	PN4392-18		5192	TO-92
ITE4393	N	TO-106	PN4393-18		5192	TO-92
ITE4416	N	TO-106	PN4416-18		5092	TO-92

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
ITE4867	N	TO-106		PN3686-18	5292	TO-92
ITE4868	N	TO-106		PN3685-18	5292	TO-92
J108	N	TO-92	J108		5892	TO-92
J109	N	TO-92	J109		5892	TO-92
J110	N	TO-92	J110		5892	TO-92
J111	N	TO-92	J111		5192	TO-92
J111A	N	TO-92		PN4091	5192	TO-92
J112	N	TO-92	J112		5192	TO-92
J112A	N	TO-92		PN4092	5192	TO-92
J113	N	TO-92	J113		5192	TO-92
J113A	N	TO-92		PN4093	5192	TO-92
J114	N	TO-92	J114		9092	TO-92
J174	N	TO-92	J174		8894	TO-92
J175	P	TO-92	J175		8894	TO-92
J176	P	TO-92	J176		8894	TO-92
J177	P	TO-92	J177		8894	TO-92
J201	N	TO-92	J201		5292	TO-92
J202	N	TO-92	J202		5294	TO-92
J203	N	TO-92	J203		5292	TO-92
J210	N	TO-92	J210		9092	TO-92
J211	N	TO-92	J211		9092	TO-92
J212	N	TO-92	J212		9092	TO-92
J230	N	TO-92		J202	5292	TO-92
J231	N	TO-92		J202	5292	TO-92
J232	N	TO-92		J203	5292	TO-92
J270	P	TO-92	J270		8894	TO-92
J271	P	TO-92	J271		8894	TO-92
J300	N	TO-92	J300		9092	TO-92
J304	N	TO-92	J304		5092	TO-92
J305	N	TO-92	J305		5092	TO-92
J308	N	TO-92	J308		9292	TO-92
J309	N	TO-92	J309		9292	TO-92
J310	N	TO-92	J310		9292	TO-92
J401	N	MiniDIP	J401		9860	MiniDIP
J402	N	MiniDIP	J402		9860	MiniDIP

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Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
J403	N	MiniDIP	J403		9860	MiniDIP
J404	N	MiniDIP	J404		9860	MiniDIP
J405	N	MiniDIP	J405		9860	MiniDIP
J406	N	MiniDIP	J406		9860	MiniDIP
J410	N	MiniDIP	J410		8360	MiniDIP
J411	N	MiniDIP	J411		8360	MiniDIP
J412	N	MiniDIP	J412		8360	MiniDIP
J3970	N	TO-92		PN4391	5192	TO-92
J3971	N	TO-92		PN4392	5192	TO-92
J3972	N	TO-92		PN4393	5192	TO-92
J4091	N	TO-92	PN4091		5192	TO-92
J4092	N	TO-92	PN4092		5192	TO-92
J4093	N	TO-92	PN4093		5192	TO-92
J4220	N	TO-92	PN4220		5592	TO-92
J4221	N	TO-92	PN4221		5592	TO-92
J4222	N	TO-92	PN4222		5592	TO-92
J4223	N	TO-92	PN4223		5092	TO-92
J4224	N	TO-92	PN4224		5092	TO-92
J4302	N	TO-92	PN4302		5292	TO-92
J4303	N	TO-92	PN4303		5292	TO-92
J4304	N	TO-92	PN4304		5292	TO-92
J4338	N	TO-92		PN3687	5292	TO-92
J4339	N	TO-92		PN3686	5292	TO-92
J4391	N	TO-92	PN4391		5192	TO-92
J4392	N	TO-92	PN4392		5192	TO-92
J4393	N	TO-92	PN4393		5192	TO-92
J4416	N	TO-92	PN4416		5092	TO-92
J4856	N	TO-92	PN4856		5192	TO-92
J4857	N	TO-92	PN4857		5192	TO-92
J4858	N	TO-92	PN4858		5192	TO-92
J4859	N	TO-92	PN4859		5192	TO-92
J4860	N	TO-92	PN4860		5192	TO-92
J4861	N	TO-92	PN4861		5192	TO-92
J5103	N	TO-92		J305	5092	TO-92
J5104	N	TO-92		J305	5092	TO-92

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
J5105	N	TO-92		J304	5092	TO-92
K114-18	N			J114	9092	TO-92
K210-18	N		J210-18		9092	TO-92
K211-18	N		J211-18		9092	TO-92
K212-18	N		J212-18		9092	TO-92
K300-18	N		J300-18		9092	TO-92
K304-18	N		J304-18		5092	TO-92
K305-18	N		J305-18		5092	TO-92
K308-18	N		J308-18		9292	TO-92
K309-18	N		J308-18		9292	TO-92
K310-18	N		J310-18		9292	TO-92
KE510	N	TO-106		J111	5192	TO-92
KE511	N	TO-106		J111	5192	TO-92
KE3684	N	TO-106	PN3684-18		5292	TO-92
KE3685	N	TO-106	PN3685-18		5292	TO-92
KE3686	N	TO-106	PN3686-18		5292	TO-92
KE3687	N	TO-106	PN3687-18		5292	TO-92
KE3823	N	TO-106		PN4224-18	5092	TO-92
KE3970	N	TO-106		PN4391-18	5192	TO-92
KE3971	N	TO-106		PN4392-18	5192	TO-92
KE3972	N	TO-106		PN4393-18	5192	TO-92
KE4091	N	TO-106	PN4091-18		5192	TO-92
KE4092	N	TO-106	PN4092-18		5192	TO-92
KE4093	N	TO-106	PN4093-18		5192	TO-92
KE4220	N	TO-106	PN4220-18		5592	TO-92
KE4221	N	TO-106	PN4221-18		5592	TO-92
KE4222	N	TO-106	PN4222-18		5592	TO-92
KE4223	N	TO-106	PN4223-18		5092	TO-92
KE4224	N	TO-106	PN4224-18		5092	TO-92
KE4391	N	TO-106	PN4391-18		5192	TO-92
KE4392	N	TO-106	PN4392-18		5192	TO-92
KE4393	N	TO-106	PN4393-18		5192	TO-92
KE4416	N	TO-106	PN4416-18		5092	TO-92
KE4856	N	TO-106	PN4856-18		5192	TO-92
KE4857	N	TO-106	PN4857-18		5192	TO-92

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Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
KE4858	N	TO-106	PN4858-18		5192	TO-92
KE4859	N	TO-106	PN4859-18		5192	TO-92
KE4860	N	TO-106	PN4860-18		5192	TO-92
KE4861	N	TO-106	PN4861-18		5192	TO-92
KE5103	N	TO-106		J305-18	5092	TO-92
KE5104	N	TO-106		J305-18	5092	TO-92
KE5105	N	TO-106		J304-18	5092	TO-92
KK4416-18	N	PN4416-18			5092	TO-92
MFE2000	N	TO-72		2N4416	5025	TO-72
MFE2001	N	TO-72		2N4416	5025	TO-72
MFE2004	N	TO-18		2N4093	5102	TO-18
MFE2005	N	TO-18		2N4092	5102	TO-18
MFE2006	N	TO-18	2N4091		5102	TO-18
MFE2007	N	TO-18	2N4857		5102	TO-18
MFE2008	N	TO-18	2N4391		5102	TO-18
MFE2009	N	TO-18	2N4856		5102	TO-18
MFE2010	N	TO-18	2N4856		5102	TO-18
MFE2011	N	TO-18	2N5433		5807	TO-52
MFE2012	N	TO-18	2N5433		5807	TO-52
MFE4007	P	TO-72	2N5020		8911	TO-18
MFE4008	P	TO-72	2N2608		8911	TO-18
MFE4009	P	TO-72	2N3329		8923	TO-72
MFE4010	P	TO-72	2N3330		8923	TO-72
MFE4011	P	TO-72	2N3331		8923	TO-72
MPF102	N	TO-92	MPF102		5092	TO-92
MPF103	N	TO-92	MPF103		5592	TO-92
MPF104	N	TO-92	MPF104		5092	TO-92
MPF105	N	TO-92	MPF105		5592	TO-92
MPF106	N	TO-92	MPF106		5092	TO-92
MPF107	N	TO-92	MPF107		5092	TO-92
MPF108	N	TO-92	MPF108		5092	TO-92
MPF109	N	TO-92	MPF109		5092	TO-92
MPF110	N	TO-92	MPF110		5092	TO-92
MPF111	N	TO-92	MPF111		5092	TO-92
MPF112	N	TO-92	MPF112		5092	TO-92

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
MPF161	P	TO-92		2N5461	8991	TO-92
MPF256	N	TO-92	MPF256		9092	TO-92
MPF820	N	TO-92	MPF820		9292	TO-92
MPF970	P	TO-92		P1086	8891	TO-92
MPF971	P	TO-92		P1087	8891	TO-92
MPF4391	N	TO-92	PN4391		5192	TO-92
MPF4392	N	TO-92	PN4392		5192	TO-92
MPF4393	N	TO-92	PN4393		5192	TO-92
NDF9401	N	TO-78		NDF9406	9412	TO-71
NDF9402	N	TO-78		NDF9407	9412	TO-71
NDF9403	N	TO-78		NDF9408	9412	TO-71
NDF9404	N	TO-78		NDF9409	9412	TO-71
NDF9405	N	TO-78		NDF9410	9412	TO-71
NDF9406	N	TO-71	NDF9406		9412	TO-71
NDF9407	N	TO-71	NDF9407		9412	TO-71
NDF9408	N	TO-71	NDF9408		9412	TO-71
NDF9409	N	TO-71	NDF9409		9412	TO-71
NDF9410	N	TO-71	NDF9410		9412	TO-71
NF500	N	TO-72		2N4224	5025	TO-72
NF501	N	TO-72		2N4224	5025	TO-72
NF506	N	TO-72		2N3823	5025	TO-72
NF510	N	TO-18		2N4092	5102	TO-18
NF511	N	TO-18		2N4092	5102	TO-18
NF520	N	TO-72		2N4224	5025	TO-72
NF521	N	TO-72		2N4220	5525	TO-72
NF522	N	TO-72		2N4224	5025	TO-72
NF523	N	TO-72		2N4220	5525	TO-72
NF530	N	TO-18		2N3822	5525	TO-72
NF531	N	TO-18		2N3821	5525	TO-72
NF532	N	TO-18		2N3822	5525	TO-72
NF533	N	TO-18		2N3821	5525	TO-72
NF3819	N	TO-18	2N3819-18		5094	TO-92
NF4302	N	TO-18	PN4302-18		5292	TO-92
NF4303	N	TO-18	PN4303-18		5292	TO-92
NF4304	N	TO-18	PN4304-18		5292	TO-92

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Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
NF4445	N	TO-18		2N5432	5807	TO-52	PN4221	N	TO-92	PN4221		5592	TO-92
NF4446	N	TO-18		2N5433	5807	TO-52	PN4222	N	TO-92	PN4222		5592	TO-92
NF4447	N	TO-18		2N5432	5807	TO-52	PN4223	N	TO-92	PN4223		5092	TO-92
NF4448	N	TO-18		2N4856	5807	TO-52	PN4224	N	TO-92	PN4224		5092	TO-92
NF5101	N	TO-72	NF5101		5125	TO-72	PN4302	N	TO-92	PN4302		5292	TO-92
NF5102	N	TO-72	NF5102		5125	TO-72	PN4303	N	TO-92	PN4303		5292	TO-92
NF5103	N	TO-72	NF5103		5125	TO-72	PN4304	N	TO-92	PN4304		5292	TO-92
NF5163	N	TO-18	PN5163-18		5072	TO-72	PN4342	N	TO-92	PN4342		8991	TO-92
NF5457	N	TO-18	2N5457-18		5592	TO-92	PN4360	N	TO-92	PN4360		8991	TO-92
NF5458	N	TO-18	2N5458-18		5592	TO-92	PN4391	N	TO-92	PN4391		5192	TO-92
NF5459	N	TO-18	2N5459-18		5592	TO-92	PN4392	N	TO-92	PN4392		5192	TO-92
NF5484	N	TO-18	2N5484-18		5092	TO-92	PN4393	N	TO-92	PN4393		5192	TO-92
NF5485	N	TO-18	2N5485-18		5092	TO-92	PN4416	N	TO-92	PN4416		5092	TO-92
NF5486	N	TO-18	2N5486-18		5092	TO-92	PN4856	N	TO-92	PN4856		5192	TO-92
NF5555	N	TO-72	2N5555-18		5092	TO-92	PN4857	N	TO-92	PN4857		5192	TO-92
NF5638	N	TO-18	2N5638-18		5192	TO-92	PN4858	N	TO-92	PN4858		5192	TO-92
NF5639	N	TO-18	2N5639-18		5192	TO-92	PN4859	N	TO-92	PN4859		5192	TO-92
NF5640	N	TO-18	2N5640-18		5192	TO-92	PN4860	N	TO-92	PN4860		5192	TO-92
NF5653	N	TO-18	2N5653-18		5192	TO-92	PN4861	N	TO-92	PN4861		5192	TO-92
NF5654	N	TO-18	2N5654-18		5192	TO-92	PN5033	N	TO-92	PN5033		8991	TO-92
P1086E	P	TO-106	P1086-18		8891	TO-92	PN5163	N	TO-92	PN5163		5092	TO-92
P1087E	P	TO-106	P1087-18		8891	TO-92	SU2000	N	TO-71		2N3822	5525	TO-72
PF510	P	TO-18		PN4392-18	5192	TO-92	SU2020	N	TO-71		2N5196	8312	TO-71
PF511	P	TO-18		PN4392-18	5192	TO-92	SU2021	N	TO-71		2N5196	8312	TO-71
PF5101	N	TO-92	PF5101		5192	TO-92	SU2022	N	TO-71		2N5196	8312	TO-71
PF5102	N	TO-92	PF5102		5192	TO-92	SU2023	N	TO-71		2N5196	8312	TO-71
PF5103	N	TO-92	PF5103		5192	TO-92	SU2024	N	TO-71		2N5196	8312	TO-71
PF3684	N	TO-92	PN3684		5292	TO-92	SU2025	N	TO-71		2N5196	8312	TO-71
PN3685	N	TO-92	PN3685		5292	TO-92	SU2026	N	TO-71		2N5196	8312	TO-71
PN3686	N	TO-92	PN3686		5292	TO-92	SU2027	N	TO-71		2N5196	8312	TO-71
PN3687	N	TO-92	PN3687		5292	TO-92	SU2028	N	TO-71		2N5196	8312	TO-71
PN4091	N	TO-92	PN4091		5192	TO-92	SU2029	N	TO-71		2N5196	8312	TO-71
PN4092	N	TO-92	PN4092		5192	TO-92	SU2030	N	TO-71		2N4082	8312	TO-71
PN4093	N	TO-92	PN4093		5192	TO-92	SU2033	N	TO-71		2N5561	8312	TO-71
PN4220	N	TO-92	PN4220		5292	TO-92	SU2034	N	TO-71		2N5561	8312	TO-71

JFET Cross Reference Guide (Continued)

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
SU2035	N	TO-71		2N5561	8312	TO-71
SU2076	N	TO-71		2N5561	8312	TO-71
SU2077	N	TO-71		2N5561	8312	TO-71
SU2078	N	TO-71		2N3955	8312	TO-71
SU2079	N	TO-71		2N3956	8312	TO-71
SU2080	N	TO-71		U404	9812	TO-71
SU2081	N	TO-71		U404	9812	TO-71
SU2098	N	TO-71		2N3954	8312	TO-71
SU2098A	N	TO-71		2N3954	8312	TO-71
SU2098B	N	TO-71		2N3954A	8312	TO-71
SU2099	N	TO-71		2N3955A	8312	TO-71
SU2099A	N	TO-71		2N3955A	8312	TO-71
SU2365	N	TO-71		U401	9812	TO-71
SU2365A	N	TO-71		U401	9812	TO-71
SU2366	N	TO-71		U402	9812	TO-71
SU2366A	N	TO-71		U402	9812	TO-71
SU2367	N	TO-71		U403	9812	TO-71
SU2367A	N	TO-71		U403	9812	TO-71
SU2368	N	TO-71		U404	9812	TO-71
SU2368A	N	TO-71		U404	9812	TO-71
SU2369	N	TO-71		U405	9812	TO-71
SU2369A	N	TO-71		U405	9812	TO-71
SU2652M	N	MiniDIP		J401	9860	MiniDIP
SU2653M	N	MiniDIP		J401	9860	MiniDIP
SU2654M	N	MiniDIP		J401	9860	MiniDIP
SU2655M	N	MiniDIP		J402	9860	MiniDIP
SU2656M	N	MiniDIP		J404	9860	MiniDIP
TD5452	N	TO-18/8		2N5452	8312	TO-71
TD5453	N	TO-18/8		2N5453	8312	TO-71
TD5454	N	TO-18/8		2N5454	8312	TO-71
TD5902	N	TO-18/8	2N5902		8424	TO-78
TD5902A	N	TO-18/8		2N5902	8424	TO-78
TD5903	N	TO-18/8	2N5903		8424	TO-78
TD5903A	N	TO-18/8		2N5903	8424	TO-78
TD5904	N	TO-18/8	2N5904		8424	TO-78
TD5904A	N	TO-18/8		2N5904	8424	TO-78

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
TD5905	N	TO-18/8		2N5905	8424	TO-78
TD5905A	N	TO-18/8		2N5905	8424	TO-78
TD5906	N	TO-18/8	2N5906		8424	TO-78
TD5906A	N	TO-18/8		2N5906	8424	TO-78
TD5907	N	TO-18/8	2N5907		8424	TO-78
TD5907A	N	TO-18/8		2N5907	8424	TO-78
TD5908	N	TO-18/8	2N5908		8424	TO-78
TD5908A	N	TO-18/8		2N5908	8424	TO-78
TD5909	N	TO-18/8	2N5909		8424	TO-78
TD5909A	N	TO-18/8		2N5909	8424	TO-78
TD5910	N	TO-18/8	2N5910		8424	TO-78
TD5910A	N	TO-18/8		2N5910	8424	TO-78
TD5911	N	TO-18/8	2N5911		9324	TO-78
TD5911A	N	TO-18/8		2N5911	9324	TO-78
TD5912	N	TO-18/8	2N5912		9324	TO-78
TD5912A	N	TO-18/8		2N5912	9324	TO-78
TIS25	N	TO-5/6		U401	9812	TO-71
TIS26	N	TO-5/6		U402	9812	TO-71
TIS27	N	TO-5/6		U403	9812	TO-71
TIS34	N	TO-92		2N5486	5092	TO-92
TIS41	N	TO-18		2N4859	5192	TO-92
TIS42	N	TO-92		PN4392	5192	TO-92
TIS58	N	TO-92	TIS58		5094	TO-92
TIS59	N	TO-92	TIS59		5094	TO-92
TIS73	N	TO-18	TIS73		5197	TO-92
TIS74	N	TO-18	TIS74		5197	TO-92
TIS75	N	TO-18	TIS75		5197	TO-92
TIS88A	N	TO-18		2N5486	5092	TO-92
TP5114	P	TO-18	2N5114		8811	TO-18
TP5115	P	TO-18	2N5115		8811	TO-18
TP5116	P	TO-18	2N5116		8811	TO-18
U110	P	TO-18		2N5020	8911	TO-18
U112	P	TO-18		2N4318	8911	TO-18
U146	P	TO-18		2N5020	8911	TO-18
U147	P	TO-18		2N5020	8911	TO-18
U148	P	TO-18		2N2608	8911	TO-18

JFET Cross Reference Guide (Continued)

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
U183	N	TO-72		2N3823	5025	TO-72
U184	N	TO-72		2N4416	5025	TO-72
U197	N	TO-18		2N4338	5202	TO-18
U198	N	TO-18		2N4340	5202	TO-18
U199	N	TO-18		2N4341	5202	TO-18
U200	N	TO-18		2N4393	5102	TO-18
U201	N	TO-18		2N4392	5102	TO-18
U202	N	TO-18		2N4391	5102	TO-18
U231	N	TO-71	U231		8312	TO-71
U232	N	TO-71	U232		8312	TO-71
U233	N	TO-71	U233		8312	TO-71
U234	N	TO-71	U234		8312	TO-71
U235	N	TO-71	U235		8312	TO-71
U257	N	TO-78	U257		9324	TO-78
U300	P	TO-18		2N5114	8811	TO-18
U301	P	TO-18		2N5145	8811	TO-18
U304	P	TO-18		2N5114	8811	TO-18
U305	P	TO-18		2N5116	8811	TO-18
U308	N	TO-52	U308		9207	TO-52
U309	N	TO-52	U309		9207	TO-52
U310	N	TO-52	U310		9207	TO-52
U312	N	TO-18	U312		9007	TO-52
U316	N	B-69	U309		9207	TO-52
U317	N	B-69	U310		9207	TO-52
U320	N	TO-5		2N5433	5807	TO-52
U321	N	TO-5		2N5433	5807	TO-52
U322	N	TO-5		2N5432	5807	TO-52
U401	N	TO-71	U401		9812	TO-71
U402	N	TO-71	U402		9812	TO-71
U403	N	TO-71	U403		9812	TO-71
U404	N	TO-71	U404		9812	TO-71
U405	N	TO-71	U405		9812	TO-71
U406	N	TO-71	U406		9812	TO-71
U440	N	TO-71		2N5911	9324	TO-78
U441	N	TO-71		2N5912	9324	TO-78

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
U1837E	N	TO-106		2N5486-18	5092	TO-92
U1897	N	TO-106	U1897		5192	TO-92
U1897E	N	TO-106		U1897-18	5192	TO-92
U1898	N	TO-106	U1898		5192	TO-92
U1898E	N	TO-106		U1898-18	5192	TO-92
U1899	N	TO-106	U1899		5192	TO-92
U1899E	N	TO-106		U1899-18	5192	TO-92
U1994	N	TO-106		PN4416-18	5092	TO-92
U1994E	N	TO-106		PN4416-18	5092	TO-92
U2047	N	TO-92		PN4416	5092	TO-92
U2047E	N	TO-106		PN4416-18	5092	TO-92
UC155	N	TO-72		2N4416	5025	TO-72
UC200	N	TO-72		2N4393	5102	TO-18
UC201	N	TO-72		2N4416	5025	TO-72
UC220	N	TO-72		2N4220	5525	TO-72
UC241	N	TO-72		2N3822	5525	TO-72
UC250	N	TO-18		2N4391	5102	TO-18
UC251	N	TO-18		2N4392	5102	TO-18
UC400	P	TO-72		2N2609	8811	TO-18
UC401	P	TO-72		2N5019	8811	TO-18
UC410	P	TO-72		2N2609	8811	TO-18
UC420	P	TO-72		2N3329	8923	TO-72
UC588	N	TO-106		PN4416-18	5092	TO-92
UC703	N	TO-72		2N3822	5525	TO-72
UC705	N	TO-72		2N3824	5525	TO-72
UC707	N	TO-18		2N4391	5102	TO-18
UC714	N	TO-72		2N4416	5025	TO-72
UC734	N	TO-72		2N4416	5025	TO-72
UC734E	N	TO-106		PN4416-18	5092	TO-92
UC755	N	TO-18		2N4391	5102	TO-18
UC756	N	TO-18		2N4224	5025	TO-72
UC805	P	TO-72		2N3331	8923	TO-72
UC807	P	TO-72		2N4861	5102	TO-18
UC814	P	TO-72		2N3331	8923	TO-72
UC851	P	TO-18		2N2608	8911	TO-18

National Semiconductor

Ultra-Fast Recovery Rectifier Cross Reference Guide

Ultra-Fast Reverse Recovery Rectifiers

Industry Type	Part No.
BYV32-100	FRP2010CC
BYV32-150	FRP2015CC
BYV32-200	FRP2020CC
BYV32-50	FRP2005CC
BYV79-100	FRP1610
BYV79-150	FRP1615
BYV79-200	FRP1620
BYV79-50	FRP1605
BYW28-100	FRP810
BYW29-150	FRP815
BYW29-200	FRP820
BYW29-50	FRP805
BYW51-100	FRP1610CC
BYW51-150	FRP1615CC
BYW51-50	FRP1605CC
BYW80-100	FRP810
BYW80-150	FRP815
BYW80-200	FRP820
BYW80-50	FRP805
BYW99-100	FRK3210CC
BYW99-150	FRK3220CC
BYW99-50	FRK3205CC
FE16A	FRP1605
FE16B	FRP1610
FE16C	FRP1615
FE16D	FRP1620
FE8A	FRP805
FE8B	FRP810

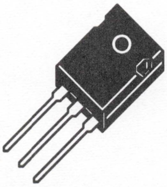
Industry Type	Part No.
FE8C	FRP815
FE8D	FRP820
MUR1505	FRP1605
MUR1510	FRP1610
MUR1515	FRP1615
MUR1520	FRP1620
MUR1605CT	FRP1605CC
MUR1610CT	FRP1610CC
MUR1615CT	FRP1615CC
MUR1620CT	FRP1620CC
MUR805	FRP805
MUR810	FRP810
MUR815	FRP815
MUR820	FRP820
RUR810	FRP810
RUR815	FRP815
RUR820	FRP820
RURD1610	FRM3210CC
RURD1615	FRM3210CC
RURD1620	FRM3220CC
RURD810	FRP1610CC
RURD815	FRP1615CC
RURD820	FRP1620CC
UES1401	FRP805
UES1402	FRP810
UES1403	FRP815
UES1404	FRP820
UES1501	FRP1605

Industry Type	Part No.
UES1502	FRP1610
UES1503	FRP1615
UES1504	FRP1620
UES2401	FRP1605CC
UES2402	FRP1610CC
UES2403	FRP1615CC
UES2404	FRP1620CC
UES2601	FRK3205CC
UES2602	FRK3210CC
UES2603	FRK3215CC
UES2604	FRK3220CC
VHE1401	FRP1005
VHE1402	FRP1010
VHE1403	FRP1015
VHE1404	FRP1020
VHE2401	FRP2005CC
VHE2402	FRP2010CC
VHE2403	FRP2015CC
VHE2404	FRP2020CC
VHE2601	FRK3205CC
VHE2602	FRK3210CC
VHE2603	FRK3215CC
VHE2604	FRK3220CC

National Semiconductor

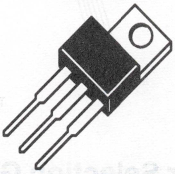
Ultra-Fast Recovery Rectifier Selection Guide

TO-3P (40)



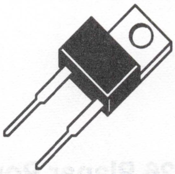
TL/G/10015–1

TO-220AB (38)



TL/G/10015–2

TO-220AC (41)



TL/G/10015–3

Single Rectifier Per Package

Part Number	V_{RSM} (V)	$I_{F(AVG)}$ (A)	t_{rr} (ns) (Note 1)	V_F(V) (Note 2)	Package Style
FRP805	50	8	50	0.95	TO-220AC (41)
FRP810	100	8	50	0.95	TO-220AC (41)
FRP815	150	8	50	0.95	TO-220AC (41)
FRP820	200	8	50	0.95	TO-220AC (41)
FRP840	400	8	75	1.50	TO-220AC (41)
FRP850	500	8	75	1.50	TO-220AC (41)
FRP860	600	8	75	1.50	TO-220AC (41)
FRP1005	50	10	50	0.95	TO-220AC (41)
FRP1010	100	10	50	0.95	TO-220AC (41)
FRP1015	150	10	50	0.95	TO-220AC (41)
FRP1020	200	10	50	0.95	TO-220AC (41)
FRP1605	50	16	50	0.95	TO-220AC (41)
FRP1610	100	16	50	0.95	TO-220AC (41)
FRP1615	150	16	50	0.95	TO-220AC (41)
FRP1620	200	16	50	0.95	TO-220AC (41)

Dual Rectifiers, Common Cathode

Part Number	V_{RSM} (V)	$I_{F(AVG)}$ (A)	t_{rr} (ns) (Note 1)	V_F(V) (Note 2)	Package Style
FRP1605CC	50	16	50	0.95	TO-220AB (38)
FRP1610CC	100	16	50	0.95	TO-220AB (38)
FRP1615CC	150	16	50	0.95	TO-220AB (38)
FRP1620CC	200	16	50	0.95	TO-220AB (38)
FRP1640CC	400	8	75	1.50	TO-220AB (38)
FRP1650CC	500	8	75	1.50	TO-220AB (38)
FRP1660CC	600	8	75	1.50	TO-220AB (38)
FRP2005CC	50	20	50	0.95	TO-220AB (38)
FRP2010CC	100	20	50	0.95	TO-220AB (38)
FRP2015CC	150	20	50	0.95	TO-220AB (38)
FRP2020CC	200	20	50	0.95	TO-220AB (38)
FRK3205CC	50	32	50	0.95	TO-3P (40)
FRK3210CC	100	32	50	0.95	TO-3P (40)
FRK3215CC	150	32	50	0.95	TO-3P (40)
FRK3220CC	200	32	50	0.95	TO-3P (40)

Note 1: Pulsed Measurement = 300 μs pulse width.

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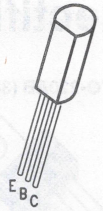

TL/G/10016–4

TO-226 Planar Power Transistor Selection Guide

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(mA)	@ V_{CE}(V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C (mA)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
2N7053		1.5	100	10k		100	5	1.5	250		125	06
MPSW01		1.5	30	55		10	1	0.5	1A		50	37
MPSW01A		1.5	40	55		10	1	0.5	1A	*	50	38
MPSW05		1.5	60	80		50	1	0.4	250		50	38
MPSW06		1	80	80		50	1	0.4	250		50	39
MPSW10		0.1	300	25		1	10	0.75	30		45	48
MPSW13		0.5	30	5k		10	5	1.5	100		125	05
MPSW14		0.5	30	10k		10	5	1.5	100		125	05
MPSW42		0.1	300	25		1	10	0.5	20	*	50	48
MPSW43		0.1	200	25		1	10	0.5	20		50	48
MPSW45		1	40	25k	150k	200	5	1.5	1A		100	05
MPSW45A		1	50	25k	150k	200	5	1.5	1A		100	05
	MPSW51	1.5	30	55		10	1	0.7	1A	*	50	77
	MPSW51A	1.5	40	55		10	1	0.7	1A		50	78
	MPSW55	1.5	60	80		50	1	0.5	250		50	78
	MPSW56	1	80	80		50	1	0.5	250		50	79
	MPSW63	0.5	30	5k		10	5	1.5	100		125	61
	MPSW64	0.5	30	10k		10	5	1.5	100	*	125	61
	MPSW92	0.1	300	40		10	10	0.5	20		50	76
	MPSW93	0.1	200	40		10	10	0.5	20		50	76

Pinout: EBC

*All TO-226AE: 1W, Free Air (T_A = 25°C)

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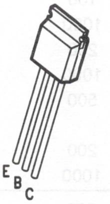

TL/G/10016-5

TO-237 Planar Power Transistor Selection Guide

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(mA)	@ V_{CE}(V)	Max $V_{CE\,(SAT)}$ (V)	@ I_C (mA)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
92PE869	92PE870	0.1	250	50		25	20			*	60	48/76
92PE871	92PE872	0.1	300	50		25	20				60	48/76
2N6711		0.1	160	30		30	10	1	30		50	48
92PE487												
2N6733		0.1	200	40		10	10	2	20		50	48
92PU391												
2N6712		0.1	250	30		30	10	1	30	*	50	48
92PE488												
2N6734		0.1	250	40		10	10	2	20		50	48
92PU392												
2N6773		0.1	300	30		30	10	1	30		50	48
92PE489												
2N6735		0.1	300	40		10	10	2	20	*	50	48
92PU393												
2N6719		0.1	300	40		30	10	0.75	30		50	48
92PU10												
TN2219		0.5	30	100	300	150	10	0.4	150		250	19
				30		500	10					
TN2218A		0.5	40	40	120	150	10	0.3	150		250	19
				25		500	10					
TN2219A	TN2905	0.5	40	100	300	150	10	0.3	150	*	300	19/63
								0.4				
	TN2904A	0.5	60	40	120	150	10	0.4	150		200	63
				40		500	10					
	TN2905A	0.5	60	100	300	150	10	0.4	150		200	63
				50		500	10					
TN3053	TN4037	1	40	50	250	150	10	1.4	150		100	12/67
2N6737		1	45	60	150	100	1	0.4	300		300	25
				40		300				*		
TN3467		1	40	40		150	1	0.4	150		175	70
				40	120	500	1	0.6	500			
TN3724		1	30	60	150	100	1	0.2	100		30	25
				40		300	1	0.32	300			
TN3725		1	50	60	150	100	1	0.4	300		300	25
				40		300						
TN2102	TN4036	1	65	40	120	150	10	0.5	150		60	12/67
				25		500	10	0.65				
TN3019		1	80	100	300	150	10	0.2	150	*	100	12
TN3020		1	80	40	120	150	10	0.2	150		100	12
	TN4033	1	80	100	300	100	5	0.15	150		150	67

*All TO-237: 850 mW, Free Air (T_A = 25°C)
2.0W, Collector Lead at 25°C
1W–1.2W Mounted Flush in PC Board

Pinout: 92PE ECB
92PU, TN EBC

TO-237 Planar Power Transistor Selection Guide (Continued)

Part Number		I_C	V_{CEO}	h_{FE}		@		Max V_{CE} (SAT)		P_D	f_T	Process
NPN	PNP	(A)	(V)	Min	Max	I_C(mA)	V_{CE}(V)	(V)	@ I_C (mA)	(W)	(MHz)	(NPN/PNP)
2N6714	2N6726	2	30	60		100	1	0.5	1000		50	37/77
92PU01	92PU51			55		1000	1					
2N6715	2N6727	2	40	60		100	1	0.5	1000		50	37/77
92PU01A	92PU51A			55		1000	1					
2N6724		1	40	25k		200	5	1	200	*	100	05
92PU45				4k		1000	5	1.5	1000			
2N6705	2N6708	2	45	40		500	2	0.5	500		50	38/78
92PE37A	92PE77A											
2N6725		1	50	25k		200	5	1	200		100	05
92PU45A				4k		1000	5	1.5	1000			
2N6706	2N6709	2	60	40		500	2	0.5	500		50	38/78
92PE37B	92PE77B											
2N6716	2N6728	2	60	20		*500	1	0.35	250		50	38/78
92PU05	92PU55											
2N6731	2N6732	1	80	100	300	350	2	0.35	350	*	50	39/79
92PU100	92PU200											
2N6707	2N6710	1	80	40		50	2	0.5	500		50	39/79
92PE37C	92PE77C											
2N6717	2N6720	1	80	20		500	1	0.35	250		50	39/79
92PU06	92PU56											
2N6720		0.5	150	30		100	10	0.5	100		10	36
92PU36				30	300	100	10					
2N6721		0.5	200	30		100	10				10	36
92PU36A				30	300	100	10					
2N6722		0.5	250	30		100	10			*	10	36
92PU36B				30	300	100	10					
2N6723		0.5	300	30		100	10				10	36
92PU36C				30	300	100	10					

Pinout:	
92PE	ECB
92PU, TN	EBC

*All TO-237: 850 mW, Free Air (T_A = 25°C)
2.0W, Collector Lead at 25°C
1W–1.2W Mounted Flush in PC Board

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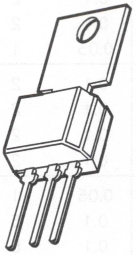

TL/G/10016-6

TO-202 Planar Power Transistor Selection Guide

Part Number		I_C	V_{CEO}	h_{FE}		@		Max $V_{CE\,(SAT)}$		P_D*	f_T	Process
NPN	PNP	(A)	(V)	Min	Max	I_C(A)	V_{CE}(V)	(V)	@ I_C (A)	(W)	(MHz)	(NPN/PNP)
NSD457		0.1	160	25		0.03	10	1	0.03	1.75	50	48
NSE457		0.1	160	25		0.03	10	1	0.03	1.75	50	48
NSD458		0.1	250	25		0.03	10	1	0.03	1.75	50	48
NSE458		0.1	250	25		0.03	10	1	0.03	1.75	50	48
D40N1		0.1	250	30	90	0.02	10			1.67	50	48
D40N2		0.1	250	60	180	0.02	10			1.67	50	48
NSD131		0.1	250	30	90	0.03	10	1	0.02	1.75	50	48
NSD132		0.1	250	60	180	0.03	10	1	0.02	1.75	50	48
NSE869	NSE870	0.1	250	50		25m	20			1.8	60	48/76
NSE871	NSE872	0.1	300	50		25m	20			1.8	60	48/76
D40N3		0.1	300	30	90	0.02	10			1.67	50	48
D40N4		0.1	300	60	180	0.02	10			1.67	50	48
NSD133		0.1	300	30	90	0.03	10	1	0.02	1.75	50	48
NSD134		0.1	300	60	180	0.03	10	1	0.02	1.75	50	48
NSD459		0.1	300	25		0.03	10	1	0.03	1.75	50	48
NSE459		0.1	300	25		0.03	10	1	0.03	1.75	50	48
NSDU10		0.1	300	40		0.03	10	1.5	0.02	1.75	60	48
D40N5		0.1	375	20		0.02	10			1.67	50	48
NSD135		0.1	375	30	90	0.03	10	1	0.02	1.75	50	48
D40C1		0.5	30	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C2		0.5	30	40k		0.2	5	1.5	0.5	1.33	75	05
D40C3		0.5	30	90k		0.2	5	1.5	0.5	1.33	75	05
D40C4		0.5	40	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C5		0.5	40	40k		0.2	5	1.5	0.5	1.33	75	05
D40C7		0.5	50	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C8		0.5	50	40k		0.2	5	1.5	0.5	1.33	75	05
D40P1		0.5	120	40		0.08	10	1	0.1	1.67	50	36
D40P3		0.5	180	40		0.08	10	1	0.1	1.67	50	36
D40P5		0.5	225	40		0.08	10	1	0.1	1.67	50	36
D40D1	D41D1	1.5	30	50	150	0.1	2	0.5	0.5	1.67	200	38/78
D40D2	D41D2	1.5	30	120	300	0.1	2	0.5	0.5	1.67	200	38/78
D40D3		1.5	30	290		0.1	2			1.67	200	38
D40D4	D41D4	1.5	45	50	150	0.1	2	0.5	0.5	1.67	200	38/78
D40D5	D41D5	1.5	45	120	360	0.1	2	0.5	0.5	1.67	200	38/78
NSD102	NSD202	1.5	45	50	150	0.1	5	0.2	0.1	1.75	60	38/78
NSD103	NSD203	1.5	45	120	360	0.1	5	0.2	0.1	1.75	60	38/78

*T_A = 25°C

TO-202 Planar Power Transistor Selection Guide (Continued)

Part Number NPN	Part Number PNP	I_C (A)	V_{CEO} (V)	h_{FE} Min	h_{FE} Max	@ I_C(A)	@ V_{CE}(V)	Max V_{CE} (SAT) (V)	@ I_C (A)	P_D (W)	f_T (MHz)	Process (NPN/PNP)
D40D7	D41D7	1.5	60	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D8	D41D8	1.5	60	120	360	0.1	2	1	0.5	1.67	200	38/78
2N6551	2N6554	1.5	60	80	250	0.05	1	0.5	0.25	2.0	75	38/78
D40D10	D41D10	1.5	75	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D11	D41D11	1.5	75	120	360	0.1	2	1	0.5	1.67	200	38/78
D40D13	D41D13	1.5	75	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D14	D41D14	1.5	75	120	360	0.1	2	1	0.5	1.67	200	38/78
2N6552	2N6555	1	80	80	250	0.05	1	0.5	0.25		75	39/79
NSD104	NSD204	1	80	50	150	0.1	5	0.2	0.1	1.75	60	39/79
NSD105	NSD205	1	80	120	360	0.1	5	0.2	0.1	1.75	60	39/79
NSD106	NSD206	1	100	50	150	0.1	5	0.2	0.1	1.75	60	39/79
2N6553	2N6556	1	100	80	250	0.05	1	0.5	0.25		75	39/79
NSD36		0.5	150	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36A		0.5	200	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36B		0.5	250	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36C		0.5	300	30	300	0.1	10	0.5	0.1	1.75	10	36
NSDU01	NSDU51	2	30	60		0.1	1	0.5	1	1.75	50	37/77
NSD151		1	30	10k	250k	0.1	5	1.5	0.1	1.75	100	05
NSD153		1	30	5k		0.1	5	1.5	0.1	1.75	100	05
D40E1	D41E1	2	30	50		0.1	2	1	1	1.3		37/77
D40K1	D41K1	2	30	10k		0.2	5	1.5	1.5	1.67	75	37/77
D40K3	D41K3	2	30	10k		0.2	5	1.5	1.0	1.67	75	37/77
NSDU01A	NSDU51A	2	40	60		0.1	1	0.5	1	1.75	50	37/77
NSDU02	NSDU52	2	40	50	300	0.15	10	0.4	0.15	1.75	50	37/77
2N6548		1	40	15k		0.2	5	1.5	1	1.75	100	05
2N6549		1	40	25k		0.2	5	1.5	1	1.75	100	05
NSDU45		1	40	25k	150k	0.2	5	1	0.2	1.75	100	05
NSD152		1	40	10k	250k	0.1	5	1.5	1	1.75	100	05
NSD154		1	40	5k		0.1	5	1.5	1	1.75	100	05
D40K2	D41K2	1	50	10k		0.2	5	1.5	1.5	1.67	75	05/61
D40K4	D41K4	1	50	10k		0.2	5	1.5	1.0	1.67	75	05/61
NSDU45A		1	50	25k	150k	0.2	5	1	0.2	1.75	100	05
NSDU05	NSDU55	2	60	80		0.05	1	0.5	0.25	1.75	50	38/78
D40E5	D41E5	2	60	50		0.1	2	1	1	1.3		38/78
NSDU06	NSDU56	2	80	80		0.05	1	0.5	0.25	1.75	50	39/79
D40E7	D41E7	2	80	50		0.1	2	1	1	1.3		38/78
NSDU07	NDSU57	2	100	80		0.05	1	0.5	0.25	1.75	50	39/79
D42C1	D43C1	3	30	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C2	D43C2	3	30	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C3	D43C3	3	30	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C4	D43C4	3	45	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C5	D43C5	3	45	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C6	D43C6	3	45	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C7	D43C7	3	60	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C8	D43C8	3	60	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C9	D43C9	3	60	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C10	D43C10	3	80	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C12	D43C12	3	80	40	120	0.2	1	0.5	1	2.1	50	4P/5P

Pinout:	
NSDU, NSD, D40, D41	EBC
NSE, D42, D43	BCE

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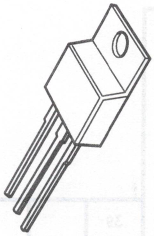


TL/G/10016-7

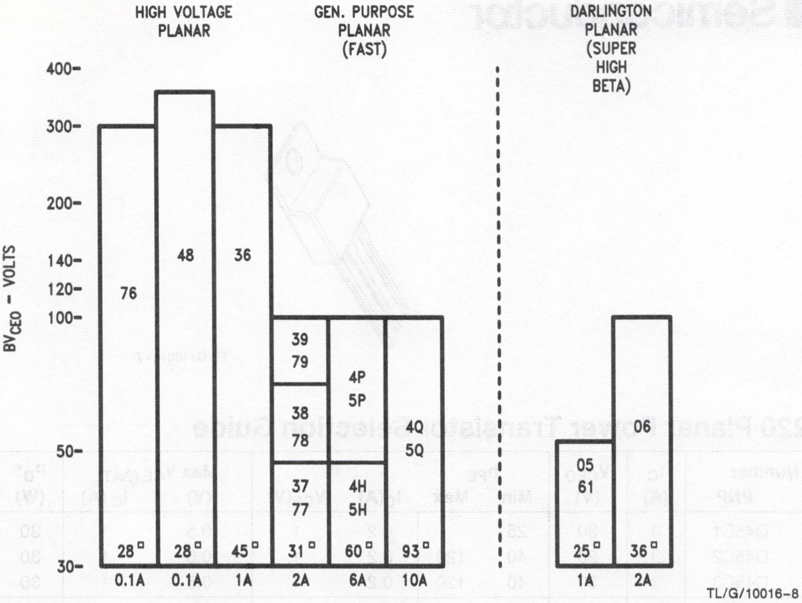
TO-220 Planar Power Transistor Selection Guide

Part Number		I_C	V_{CEO}	h_{FE}		@		Max $V_{CE\,(SAT)}$		P_D*	f_T	Process
NPN	PNP	(A)	(V)	Min	Max	I_C(A)	V_{CE}(V)	(V)	@ I_C (A)	(W)	(MHz)	(NPN/PNP)
D44C1	D45C1	3	30	25		0.2	1	0.5	1	30	50	4P/5P
D44C2	D45C2	3	30	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C3	D45C3	3	30	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C4	D45C4	3	45	25		0.2	1	0.5	1	30	50	4P/5P
D44C5	D45C5	3	45	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C6	D45C6	3	45	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C7	D45C7	3	60	25		0.2	1	0.5	1	30	50	4P/5P
D44C8	D45C8	3	60	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C9	D45C9	3	60	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C10	D45C10	3	80	25		0.2	1	0.5	1	30	50	4P/5P
D44C12	D45C12	3	80	40	120	0.2	1	0.5	1	30	50	4P/5P
D44H1	D45H1	10	30	35		2	1	1	8	50	50	4Q/5Q
D44H2	D45H2	10	30	60		2	1	1	8	50	50	4Q/5Q
D44H4	D45H4	10	45	35		2	1	1	8	50	50	4Q/5Q
D44H5	D45H5	10	45	60		2	1	1	8	50	50	4Q/5Q
D44H7	D45H7	10	60	35		2	1	1	8	50	50	4Q/5Q
D44H8	D45H8	10	60	60		2	1	1	8	50	50	4Q/5Q
D44H10	D45H10	10	80	35		2	1	1	8	50	50	4Q/5Q
D44H11	D45H11	10	80	60		2	1	1	8	50	50	4Q/5Q

Pinout: BCE

*T_C = 25°C

Planar Power Process Selection Guide



TL/G/10016-8

Dissipation (Watts)

Package								
TO-92 (Note 1)	0.6	0.6		0.6			0.6	0.7
TO-237 (Notes 1,2)	0.8	0.8	0.8	0.8			2	2
TO-226 (Notes 1,2)	1	1	1	1			10	12
TO-237 (Note 3)	2	2	2	2			0.8	0.85
TO-202 (Note 3)	8	10	15	10	15		1	1
TO-220 (Note 3)					40	60		

Note 1: T_A = 25°C

Note 2: Will do 1W–1.2W in PC Board.

Note 3: T_C = 25°C

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Substitution Guide for Non-Listed Planar Power Part-Types

Industry Part. No.	Package	NS Part No.	Package
2N2102	TO-39	TN2102	TO-237
2N2218A	TO-39	TN2218A	TO-237
2N2219A	TO-39	TN2219A	TO-237
2N2905	TO-39	TN2905	TO-237
2N3019	TO-39	TN3019	TO-237
2N3020	TO-39	TN3020	TO-237
2N3053	TO-39	TN3053	TO-237
2N3467	TO-39	TN3467	TO-237
2N3724	TO-39	TN3724	TO-237
2N3725	TO-39	TN3725	TO-237
2N4032	TO-39	TN4032	TO-237
2N4033	TO-39	TN4033	TO-237
2N4037	TO-39	TN4037	TO-237
MPSU01	Mot 152	NSDU01	TO-202
MPSU01	Mot 152	92PU01	TO-237
MPSU01A	Mot 152	NSDU01A	TO-202
MPSU01A	Mot 152	92PU01A	TO-237
MPSU02	Mot 152	NSDU02	TO-202
MPSU02	Mot 152	TN2219A	TO-237
MPSU03	Mot 152	92PU391	TO-237
MPSU04	Mot 152	92PU319	TO-237
MPSU05	Mot 152	NSDU05	TO-202
MPSU05	Mot 152	92PU05	TO-237
MPSU06	Mot 152	NSDU06	TO-202
MPSU06	Mot 152	92PU06	TO-237

Industry Part. No.	Package	NS Part No.	Package
MPSU07	Mot 152	NSDU07	TO-202
MPSU07	Mot 152	92PU07	TO-237
MPSU10	Mot 152	NSDU10	TO-202
MPSU10	Mot 152	92PU10	TO-237
MPSU31	Mot 152	TN2102	TO-237
MPSU45	Mot 152	NSDU45	TO-202
MPSU45	Mot 152	NSDU45	TO-237
MPSU45A	Mot 152	NSDU45A	TO-202
MPSU51	Mot 152	NSDU51	TO-202
MPSU51	Mot 152	92PU51	TO-237
MPSU51A	Mot 152	NSDU51A	TO-202
MPSU52	Mot 152	NSPU52	TO-202
MPSU52	Mot 152	92PU51A	TO-237
MPSU55	Mot 152	NSDU55	TO-202
MPSU55	Mot 152	92PU55	TO-237
MPSU56	Mot 152	NSDU56	TO-202
MPSU56	Mot 152	92PU56	TO-237
MPSU57	Mot 152	NSDU57	TO-202
MPSU57	Mot 152	92PU57	TO-237

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Power MOSFET Cross Reference

Power MOSFET Cross Reference

Industry Part No.	NS Part Number
2N6755	2N6755
2N6756	2N6756
2N6757	2N6757
2N6758	2N6758
2N6759	2N6759
2N6760	2N6760
2N6761	2N6761
2N6762	2N6762
2N6763	2N6763
2N6764	2N6764
2N6765	2N6765
2N6766	2N6766
2N6767	2N6767
2N6768	2N6768
2N6769	2N6769
2N6770	2N6770
2SK277	IRF333
2SK278	IRF332
2SK294	IRF522
2SK295	IRF522
2SK296	MTP3N35
2SK298	IRF332
2SK299	IRF431
2SK308	IRF243
2SK310	IRF710
2SK311	IRF823
2SK312	IRF342
2SK313	IRF441
2SK319	IRF720
2SK320	IRF723
2SK324	IRF352
2SK325	IRF453
2SK338	IRF730
2SK346	IRF523
2SK355	IRF241
2SK357	IRF623
2SK382	IRF822
2SK383	IRF530
2SK428	IRF543
2SK440	IRF630

Industry Part No.	NS Part Number
2SK512	IRF452
2SK552	IRF831
2SK553	IRF830
2SK554	IRF841
2SK555	IRF840
BUZ10	FMP18N05
BUZ10A	FMP18N05
BUZ20	IRF530
BUZ21	IRF540
BUZ21A	IRF540
BUZ23	IRF130
BUZ24	IRF150
BUZ25	IRF140
BUZ30	IRF632
BUZ31	IRF640
BUZ32	IRF630
BUZ32A	MTP12N20
BUZ34	IRF240
BUZ35	IRF230
BUZ35A	IRF230
BUZ36	IRF252
BUZ40	IRF822
BUZ41	IRF842
BUZ41A	IRF830
BUZ42	IRF832
BUZ42A	IRF832
BUZ43	IRF422
BUZ44	IRF442
BUZ44A	IRF430
BUZ44B	IRF430
BUZ45	IRF452
BUZ45B	IRF452
BUZ45C	IRF453
BUZ46	IRF432
BUZ46A	IRF430
BUZ60	IRF730
BUZ60A	IRF730
BUZ60B	IRF732
BUZ63	IRF330
BUZ63A	IRF330

Industry Part No.	NS Part Number
BUZ63B	IRF332
BUZ64	IRF352
BUZ64A	IRF352
BUZ71	FMP18N05
BUZ71A	FMP18N05
BUZ72	IRF530
BUZ72A	IRF532
BUZ73A	IRF632
BUZ74	IRF820
BUZ74A	IRF822
BUZ76	IRF720
BUZ76A	IRF722
D84BK2	IRF511
D84BL2	IRF510
D84BM2	IRF611
D84BQ1	IRF711
D84BQ2	IRF710
D84CK1	IRF521
D84CK2	IRF521
D84CL1	IRF520
D84CL2	IRF520
D84CM1	IRF621
D84CM2	IRF621
D84CN1	MTP7N18
D84CN2	IRF620
D84CQ1	IRF721
D84CQ2	IRF720
D84CR1	IRF821
D84CR2	IRF820
D84DK1	IRF531
D84DK2	IRF531
D84DL1	IRF530
D84DL2	IRF530
D84DM1	IRF631
D84DM2	IRF631
D84DN1	MTP12N18
D84DN2	IRF630
D84DQ1	IRF731
D84DQ2	IRF730
D84DR1	IRF831

Power MOSFET Cross Reference (Continued)

Industry Part No.	NS Part Number
D84DR2	IRF830
D84EK1	IRF541
D84EK2	IRF541
D84EL1	MTP4N08
D84EL2	IRF540
D84EM1	IRF641
D84EM2	IRF641
D84EN1	IRF640
D84EN2	IRF640
D84EQ1	IRF741
D84EQ2	IRF740
D84ER1	IRF841
D84ER2	IRF840
D84MN2	IRF610
D86DK1	IRF131
D86DK2	IRF131
D86DL1	IRF130
D86DL2	IRF130
D86DM1	IRF231
D86DM2	IRF231
D86DN1	IRF230
D86DN2	IRF230
D86DQ1	IRF331
D86DQ2	IRF330
D86DR1	IRF431
D86DR2	IRF430
D86EK1	IRF141
D86EL1	IRF140
D86EM1	IRF241
D86EN1	IRF240
D86EQ1	IRF341
D86EQ2	IRF340
D86ER1	IRF441
D86ER2	IRF440
D86FQ1	IRF351
D86FQ2	IRF350
D86FR1	IRF451
D86FR2	IRF450
IRFZ20	FMP18N05
IRFZ22	FMP18N05
MTP5N18	IRF520
MTP5N20	IRF520
MTP8N08	IRF522
MTP8N10	IRF522
MTP8N18	IRF630
MTP8N20	IRF630
MTP25N05	FMP20N05
PM1006P	IRF522

Industry Part No.	NS Part Number
PM1010M	IRF132
PM1010P	IRF532
PM1203P	IRF521
PM1204P	IRF633
PM1206M	IRF231
PM1206P	IRF631
PM1503P	IRF611
PM1504P	IRF623
PM1506M	IRF233
PM1506P	IRF633
PM1510M	IRF240
PM1510P	IRF643
PM509P	IRF523
PM510P	IRF521
PM512M	IRF131
PM512P	IRF531
PM518M	IRF143
PM604P	IRF513
PM605P	IRF523
PM608P	IRF521
PM609P	IRF523
PM610P	IRF521
PM612M	IRF131
PM612P	IRF531
PM614M	IRF131
PM614P	IRF531
PM618M	IRF143
PM618P	IRF543
PM804P	IRF512
PM805P	IRF522
PM808P	IRF520
PM814M	IRF130
PM814P	IRF530
PM816M	IRF152
PM816P	MTP20N08
PM820M	IRF140
PM820P	IRF540
RFK10N45	IRF453
RFK10N50	IRF452
RFK12N35	IRF353
RFK12N40	IRF352
RFK25N18	IRF252
RFK25N20	IRF252
RFK30N12	IRF251
RFK30N15	IRF251
RFK35N08	IRF150
RFK35N10	IRF150
RFM10N12	IRF243

Industry Part No.	NS Part Number
RFM10N15	IRF243
RFM12N08	IRF130
RFM12N10	IRF130
RFM12N18	IRF242
RFM12N20	IRF242
RFM15N05	IRF143
RFM15N06	IRF143
RFM15N12	IRF253
RFM15N15	IRF253
RFM18N08	IRF142
RFM18N10	IRF142
RFM25N05	IRF141
RFM25N06	IRF141
RFM4N35	IRF333
RFM4N40	IRF332
RFM6N45	IRF431
RFM6N50	IRF430
RFM7N35	MTM8N35
RFM7N40	MTM8N40
RFM8N18	IRF232
RFM8N20	IRF232
RFP10N12	IRF643
RFP10N15	IRF643
RFP12N08	IRF530
RFP12N10	IRF530
RFP12N18	IRF642
RFP12N20	IRF642
RFP15N05	IRF543
RFP15N06	IRF543
RFP18N08	IRF542
RFP18N10	IRF542
RFP25N05	FMP20N05
RFP25N06	IRF541
RFP2N08	IRF512
RFP2N10	IRF512
RFP2N12	IRF611
RFP2N15	IRF611
RFP2N18	IRF612
RFP2N20	IRF612
RFP4N05	IRF513
RFP4N06	IRF513
RFP4N35	IRF733
RFP4N40	IRF732
RFP6N45	IRF841
RFP6N50	IRF840
RFP7N35	IRF741
RFP7N40	IRF740
RFP8N18	IRF630

Power MOSFET Cross Reference (Continued)

Industry Part No.	NS Part Number
RFP8N20	IRF630
RRF320	IRF320
RRF321	IRF321
RRF322	IRF322
RRF323	IRF323
RRF330	IRF330
RRF331	IRF331
RRF332	IRF332
RRF333	IRF333
RRF420	IRF420
RRF421	IRF421
RRF422	IRF422
RRF423	IRF423
RRF430	IRF430
RRF431	IRF431
RRF432	IRF432
RRF433	IRF433
RRF510	IRF510
RRF511	IRF511
RRF512	IRF512
RRF513	IRF513
RRF520	IRF520
RRF521	IRF521
RRF522	IRF522
RRF523	IRF523
RRF610	IRF610
RRF611	IRF611
RRF612	IRF612
RRF613	IRF613
RRF620	IRF620
RRF621	IRF621
RRF622	IRF622
RRF623	IRF623
RRF710	IRF710
RRF711	IRF711
RRF712	IRF712
RRF713	IRF713
RRF720	IRF720
RRF721	IRF721
RRF722	IRF722

Industry Part No.	NS Part Number
RRF723	IRF723
RRF730	IRF730
RRF731	IRF731
RRF732	IRF732
RRF733	IRF733
RRF820	IRF820
RRF821	IRF821
RRF822	IRF822
RRF823	IRF823
RRF830	IRF830
RRF831	IRF831
RRF832	IRF832
RRF833	IRF833
SD1002KD	IRF430
SD1005CD	IRF631
SD1005KD	IRF231
SD1011KD	IRF440
SD1012KD	IRF431
SD1014CD	IRF622
SD1021KD	IRF330
SD500CD	IRF833
SD500KD	IRF433
SD900KD	IRF442
STM3110	IRF341
STM3111	IRF340
STM3112	IRF453
STM360	IRF331
STM361	IRF330
STM362	IRF442
VN0800A	IRF130
VN0800D	IRF530
VN0801A	IRF132
VN0801D	IRF532
VN1000A	IRF130
VN1000D	IRF530
VN1001A	IRF132
VN1001D	IRF532
VN1106N5	IRF511
VN1110N5	IRF510
VN1116N5	IRF612

Industry Part No.	NS Part Number
VN1120N5	IRF612
VN1200A	IRF641
VN1201A	IRF643
VN1210N5	IRF520
VN1216N5	IRF620
VN1220N5	IRF620
VN2306N1	IRF143
VN2310N1	IRF142
VN2310N5	IRF542
VN2316N1	IRF242
VN2316N5	IRF642
VN2320N1	IRF242
VN2320N5	IRF642
VN2335N1	IRF341
VN2335N5	IRF741
VN2340N1	IRF340
VN2340N5	IRF740
VN2345N1	IRF433
VN2345N5	IRF843
VN2350N1	IRF442
VN2350N5	IRF842
VN3500A	IRF331
VN3500D	IRF731
VN3501A	IRF333
VN3501D	IRF733
VN3502A	IRF430
VN4000A	IRF330
VN4000D	IRF730
VN4001A	IRF332
VN4001D	IRF732
VN4501A	IRF431
VN4501D	IRF831
VN4502A	IRF433
VN4502D	IRF833
VN5001A	IRF430
VN5001D	IRF830
VN5002A	IRF432
VN5002D	IRF832
VNL001A	IRF331
VNM001A	IRF330
VNN002A	IRF443
VNP002A	IRF430

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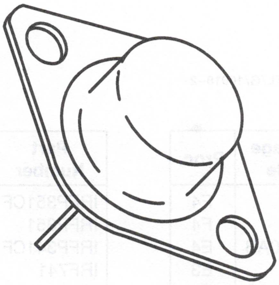
Metal TO-204AA/TO-204AE Power MOSFETs



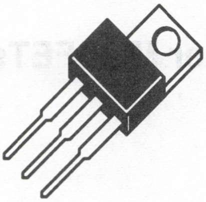
TL/G/10018–1

Part Number	V_{DSS} (V)	$R_{DS(on)}$ (Ω)	I_{DR} (A)	Package Style	Proc.
IRF450CF	500	0.320	14.5	TO-204AA	F4
IRF450		0.400	13.0	TO-204AA	F4
2N6770		0.400	12.0	TO-204AA	F4
IRF452		0.500	12.0	TO-204AA	F4
IRF440		0.850	8.0	TO-204AA	E3
IRF442		1.100	7.0	TO-204AA	E4
IRF430		1.500	4.5	TO-204AA	C4
2N6762		1.500	4.5	TO-204AA	C4
IRF432		2.000	4.0	TO-204AA	C4
IRF451	450	0.400	13.0	TO-204AA	F4
IRF453		0.500	12.0	TO-204AA	F4
2N6769		0.500	11.0	TO-204AA	F4
IRF441		0.850	8.0	TO-204AA	E4
IRF443		1.100	7.0	TO-204AA	E4
IRF431		1.500	4.5	TO-204AA	C4
IRF433		2.000	4.0	TO-204AA	C4
2N6761		2.000	4.0	TO-204AA	C4
IRF350CF	400	0.240	16.8	TO-204AA	F3
IRF350		0.300	15.0	TO-204AA	F3
IRF352		0.400	13.0	TO-204AA	F3
2N6768		0.300	14.0	TO-204AA	F3
IRF340		0.550	10.0	TO-204AA	E3
IRF342		0.800	8.0	TO-204AA	E3
IRF330		1.000	5.5	TO-204AA	C3
2N6760		1.000	5.5	TO-204AA	C3
IRF332		1.500	4.5	TO-204AA	C3
IRF351	350	0.300	15.0	TO-204AA	F3
IRF353		0.400	13.0	TO-204AA	F3
2N6767		0.400	12.0	TO-204AA	F3
IRF341		0.550	10.0	TO-204AA	F3
IRF343		0.800	8.0	TO-204AA	E3
IRF331		1.000	5.5	TO-204AA	C3
IRF333		1.500	4.5	TO-204AA	C3
2N6759		1.500	4.5	TO-204AA	C3

Part Number	V_{DSS} (V)	$R_{DS(on)}$ (Ω)	I_{DR} (A)	Package Style	Proc.
IRF250CF	200	0.068	33.0	TO-204AE	F3
2N6766		0.085	30.0	TO-204AE	F2
IRF250		0.085	30.0	TO-204AE	F3
IRF252		0.120	25.0	TO-204AE	F3
IRF240		0.180	18.0	TO-204AA	E2
IRF242		0.220	16.0	TO-204AA	E2
2N6758		0.400	9.0	TO-204AA	C2
IRF230		0.400	9.0	TO-204AA	C2
IRF232		0.500	8.0	TO-204AA	C2
IRF251	150	0.085	30.0	TO-204AE	F3
2N6765		0.120	25.0	TO-204AE	F2
IRF253		0.120	25.0	TO-204AE	F3
IRF241		0.180	18.0	TO-204AA	E2
IRF243		0.220	16.0	TO-204AA	E2
IRF231		0.400	9.0	TO-204AA	C2
IRF233		0.500	8.0	TO-204AA	C2
2N6757		0.600	8.0	TO-204AA	C2
IRF150CF	100	0.044	44.0	TO-204AE	F1
IRF150		0.055	40.0	TO-204AE	F1
2N6764		0.055	38.0	TO-204AE	F1
IRF152		0.080	33.0	TO-204AE	F1
IRF140		0.085	27.0	TO-204AE	E1
IRF142		0.110	24.0	TO-204AE	E1
2N6756		0.180	14.0	TO-204AA	C1
IRF130		0.180	14.0	TO-204AA	C1
IRF132		0.250	12.0	TO-204AA	C1
IRF151	60	0.055	40.0	TO-204AE	F1
2N6763		0.080	31.0	TO-204AE	F3
IRF153		0.080	33.0	TO-204AE	F1
IRF141		0.085	27.0	TO-204AE	E1
IRF143		0.110	24.0	TO-204AE	E1
IRF131		0.180	14.0	TO-204AA	C1
2N6755		0.250	12.0	TO-204AA	C1
IRF133		0.250	12.0	TO-204AA	C1

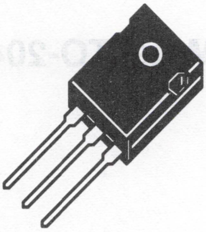
Plastic Encapsulated TO-220AB/TO-3P Power MOSFETs

TO-220AB



TL/G/10018-2

TO-3P

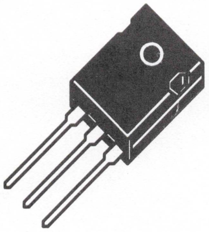


TL/G/10018-3

Part Number	V_{DSS} (V)	$R_{DS(on)}$ (Ω)	I_{DR} (A)	Package Style	Proc.
IRFP450CF	500	0.320	15.5	TO-3P	F4
IRFP450		0.400	14.0	TO-3P	F4
IRF840CF		0.680	8.9	TO-220AB	E4
IRFP440C		0.680	10.5	TO-3P	E3
IRF840		0.850	8.0	TO-220AB	E4
IRFP440		0.850	8.8	TO-3P	E3
IRF842		1.100	7.0	TO-220AB	E4
IRF830CF		1.200	5.0	TO-220AB	C4
IRF830		1.500	4.5	TO-220AB	C4
MTP4N50		1.500	4.0	TO-220AB	C4
IRF832		2.000	4.0	TO-220AB	C4
IRF820CF		2.400	2.8	TO-220AB	B5
IRF820		3.000	2.5	TO-220AB	B5
IRF822		4.000	2.0	TO-220AB	B5
MTP2N50		4.000	2.5	TO-220AB	B5
IRFP451CF	450	0.320	15.5	TO-3P	F4
IRFP451		0.400	14.0	TO-3P	F4
IRFP441CF		0.680	10.5	TO-3P	F4
IRF841		0.850	8.0	TO-220AB	E4
IRFP441		0.850	8.8	TO-3P	E4
IRF843		1.100	7.0	TO-220AB	E4
MTP4N45		1.500	4.0	TO-220AB	C4
IRF831		1.500	4.5	TO-220AB	C4
IRF833		2.000	4.0	TO-220AB	C4
IRF821		3.000	2.5	TO-220AB	B5
IRF823		4.000	2.0	TO-220AB	B5
MTP2N45		4.000	2.5	TO-220AB	B5
IRFP350CF	400	0.240	18.0	TO-3P	F3
IRFP350		0.300	16.2	TO-3P	F3
IRF740CF		0.440	11.0	TO-220AB	E3
IRFP340CF		0.440	12.0	TO-3P	E3
IRF740		0.550	10.0	TO-220AB	E3
IRFP340		0.550	11.0	TO-3P	E3
IRF742		0.800	8.0	TO-220AB	E3
IRF730CF		0.800	6.2	TO-220AB	C3
IRF730		1.000	5.5	TO-220AB	C3
MTP5N40		1.000	5.0	TO-220AB	C3
IRF720CF		1.440	3.8	TO-220AB	B4
IRF732		1.500	4.5	TO-220AB	C3
IRF720		1.800	3.0	TO-220AB	B4
IRF722		2.500	2.5	TO-220AB	B4
MTP3N40		3.300	3.0	TO-220AB	B4
IRF710		3.600	1.5	TO-220AB	A3
IRF712		5.000	1.3	TO-220AB	A3
MTP2N40		5.000	2.0	TO-220AB	A3

Part Number	V_{DSS} (V)	$R_{DS(on)}$ (Ω)	I_{DR} (A)	Package Style	Proc.
IRFP351CF	350	0.240	18.0	TO-3P	F3
IRFP351		0.300	16.2	TO-3P	F3
IRFP341CF		0.440	12.0	TO-3P	E3
IRF741		0.550	10.0	TO-220AB	E3
IRFP341		0.550	11.0	TO-3P	E3
IRF743		0.800	8.0	TO-220AB	E3
IRF731		1.000	5.5	TO-220AB	C3
MTP5N35		1.000	5.0	TO-220AB	C3
IRF733		1.500	4.5	TO-220AB	C3
IRF721		1.800	3.0	TO-220AB	B4
IRF723		2.500	2.5	TO-220AB	B4
MTP3N35		3.300	3.0	TO-220AB	B4
IRF711		3.600	1.5	TO-220AB	A3
IRF713		5.000	1.3	TO-220AB	A3
MTP2N35		5.000	2.0	TO-220AB	A3
IRFP250CF	200	0.068	35.9	TO-3P	F3
IRFP250		0.085	32.5	TO-3P	F3
IRF640CF		0.144	20.0	TO-220AB	E2
IRFP240CF		0.144	22.0	TO-3P	E2
IRF640		0.180	18.0	TO-220AB	E2
IRFP240		0.180	19.8	TO-3P	E2
IRF642		0.220	16.0	TO-220AB	E2
IRF630CF		0.320	10.0	TO-220AB	C2
MTP12N20		0.350	12.0	TO-220AB	C2
IRF630		0.400	9.0	TO-220AB	C2
IRF632		0.500	8.0	TO-220AB	C2
IRF620CF		0.640	5.6	TO-220AB	B3
MTP7N20		0.700	7.0	TO-220AB	B3
IRF620		0.800	5.0	TO-220AB	B3
IRF622		1.200	4.0	TO-220AB	B3
IRF610		1.500	2.5	TO-220AB	A2
MTP2N20		1.800	3.5	TO-220AB	A2
IRF612		2.400	2.0	TO-220AB	A2
MTP12N18	180	0.350	12.0	TO-220AB	C2
MTP7N18		0.700	7.0	TO-220AB	B3
MTP2N18		1.800	3.25	TO-220AB	A2
IRFP251CF	150	0.068	35.9	TO-3P	F3
IRFP251		0.085	32.5	TO-3P	F3
IRFP241CF		0.144	22.0	TO-3P	E2
IRF641		0.180	18.0	TO-220AB	E2
IRFP241		0.180	19.8	TO-3P	E2
IRF643		0.220	16.0	TO-220AB	E2

Plastic Encapsulated TO-220AB/TO-3P (Continued)



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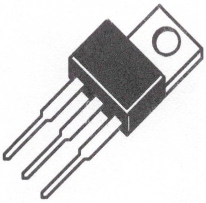

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Part Number	V_{DSS} (V)	$R_{DS(on)}$ (Ω)	I_{DR} (A)	Package Style	Proc.
IRF631	150	0.400	9.0	TO-220AB	C2
IRF633		0.500	8.0	TO-220AB	C2
IRF621		0.800	5.0	TO-220AB	B3
IRF623		1.200	4.0	TO-220AB	B3
IRF611		1.500	2.5	TO-220AB	A2
IRF613		2.400	2.0	TO-220AB	A2
IRFP150CF	100	0.044	47.5	TO-3P	F1
IRFP150		0.055	43.0	TO-3P	F1
IRF540CF		0.068	30.0	TO-220AB	E1
IRFP140CF		0.068	33.0	TO-3P	E1
IRF540		0.085	27.0	TO-220AB	E1
IRFP140		0.085	29.5	TO-3P	E1
IRF542		0.110	24.0	TO-220AB	E1
IRF530CF		0.144	16.0	TO-220AB	C3

Part Number	V_{DSS} (V)	$R_{DS(on)}$ (Ω)	I_{DR} (A)	Package Style	Proc.
MTP20N10		0.150	20.0	TO-220AB	C2
IRF530		0.180	14.0	TO-220AB	C3
IRF520CF		0.240	9.1	TO-220AB	B2
IRF532		0.250	12.0	TO-220AB	C3
IRF520		0.300	8.0	TO-220AB	B2
MTP10N10		0.330	10.0	TO-220AB	C2
IRF522		0.400	7.0	TO-220AB	B2
IRF510		0.600	4.0	TO-220AB	A1
IRF512	100	0.800	3.5	TO-220AB	A1
MTP4N10		0.800	5.0	TO-220AB	A1
MTP20N08	80	0.150	20.0	TO-220AB	C1
MTP10N08		0.330	10.0	TO-220AB	C2
MTP4N08		0.800	5.0	TO-220AB	A1
IRFP151CF	60	0.044	47.5	TO-3P	F1
IRFP151		0.055	43.0	TO-3P	F1
IRFP141CF		0.068	33.0	TO-3P	E1
IRF541		0.085	27.0	TO-220AB	E1
IRFP141		0.085	29.5	TO-3P	E1
FMP18N06		0.085	20.0	TO-220AB	B1
FMP20N06		0.100	18.0	TO-220AB	B1
IRF543		0.110	24.0	TO-220AB	E1
IRF531		0.180	14.0	TO-220AB	C3
IRF533		0.250	12.0	TO-220AB	C3
IRF521		0.300	8.0	TO-220AB	B2
IRF523		0.400	7.0	TO-220AB	B2
IRF511		0.600	4.0	TO-220AB	A1
IRF513		0.800	3.5	TO-220AB	A1
FMP20N05	50	0.085	20.0	TO-220AB	B1
FMP18N05		0.100	18.0	TO-220AB	B1

Section 2

Diodes

Section 2 Contents

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National Semiconductor

Diode Data

Computer Diodes (Glass Package)

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Min	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N625	DO-35	30	1000	20		1.5	4		1000	(Note 1)	D4
1N914	DO-35	100	25 5000	20 75		1.0	10		4	(Note 2)	D4
1N914A	DO-35	100	25 5000	20 75		1.0	20		4	(Note 2)	D4
1N914B	DO-35	100	25 5000	20 75		0.72 1.0	5 100		4	(Note 2)	D4
1N916	DO-35	100	25 5000	20 75		1.0	10		4	(Note 2)	D4
1N916A	DO-35	100	25 5000	20 75		1.0	20		4	(Note 2)	D4
1N916B	DO-35	100	25 5000	20 75		0.73 1.0	5 30		4	(Note 2)	D4
1N3064	DO-35	75	100	50		0.575 0.650 0.710 1.0	0.250 1.0 2.0 10.0	2	4	(Note 3)	D4
1N3600	DO-35	75	100	50	0.54 0.66 0.76 0.82 0.87	0.62 0.74 0.86 0.92 1.0	1.0 10.0 50.0 100.0 200.0	2.5	4	(Note 4)	D4
1N4009	DO-35	35	100	25		1.0	30	4	2	(Note 2)	D4
1N4146	DO-35	See Data for 1N914A/914B									
1N4147	DO-35	See Data for 1N914A/914B									
1N4148	DO-35	See Data for 1N914									
1N4149	DO-35	See Data for 1N916									
1N4150	DO-35	See Data for 1N3600									
1N4151	DO-35	75	50	50		1.0	50	4	2	(Note 2)	D4
1N4152	DO-35	40	50	30	0.49 0.53 0.59 0.62 0.70 0.74	0.55 0.59 0.67 0.70 0.81 0.88	0.1 0.25 1.0 2.0 10.0 20.0	4	2	(Note 2)	D4
1N4153	DO-35	75	50	50	See 1N4152			4	2	(Note 2)	D4
1N4154	DO-35	35	100	25		1.0	30	4	2	(Note 2)	D4

Computer Diodes (Glass Package) (Continued)

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Min	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N4244	DO−7	20	100	10		1.0	20	0.8	0.75	(Note 5)	D3
			250	15							
1N4305	DO-35	75	100	50		0.575	0.250	2	2	(Note 2)	D4
						0.650	1.0		4	(Note 3)	
						0.710	2.0				
						0.85	10.0				
1N4376	DO−7	20	100	10	0.42	0.50	0.010	1.0	750	(Note 5)	D3
					0.52	0.61	0.1				
					0.64	0.74	1.0				
					0.76	0.88	10.0				
					0.81	0.95	20.0				
					0.89	1.10	50.0				

Note 1: I_F = 30 mA, V_R = 35V, Recovery to 400 kΩ.

Note 2: I_F = 10 mA, V_R = 5V, R_L = 100Ω, Recovery to 1.0 mA.

Note 3: I_F = I_R = 10 mA, V_R = 1.0V, R_L = 100Ω.

Note 4: I_F = I_R = 10 mA to 200 mA, R_L = 100Ω.

Note 5: I_F = I_R = 10 mA, R_L = 100Ω, Recovery to 1.0 mA.

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Min	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N4446	DO-35	100	25	20		1.0	20	4.0	4.0	(Note 1)	D4
1N4447	DO-35	100	25	20		1.0	20	4.0	4.0	(Note 1)	D4
1N4448	DO-35	100	25	20		1.0	100	2.0	4.0	(Note 1)	D4
1N4449	DO-35	100	25	20		1.0	30	2.0	4.0	(Note 1)	D4
1N4450	DO-35	40	50	30	0.42	0.54	0.1	4.0	4.0	(Note 2)	D4
					0.52	0.64	1.0				
					0.64	0.76	10				
					0.80	0.92	100				
						1.0	200				
1N4454	DO-35	75	100	50		1.0	10	2.0	4.0	(Note 2)	D4
1N5282	DO-35	80	100	55	0.45	0.49	0.1	2.5	2.0	(Note 1)	D4
					0.55	0.60	1.0				
					0.67	0.725	10.0				
					0.80	0.90	100.0				
					0.92	1.10	300.0				
					1.05	1.30	500.0				
BAX13	DO-35	50	25	10		0.7	2.0	3.0	4.0	(Note 3)	D4
			50	25		1.0	20.0				
			200	50		1.53	75.0				
BAY71	DO-35	50	100	35	0.46	0.56	0.1	2.0	2.0	(Note 4)	D4
					0.57	0.69	1.0				
					0.69	0.88	10.0				
					0.76	1.0	20.0				
BAW75	DO-35	35	100	25		1.0	30		2.0	(Note 4)	D4
BAW76	DO-35	75	100	50		1.0	100		2.0	(Note 4)	D4

Computer Diodes (Glass Package) (Continued)

Device No.	Package No.	V_{RRM} V Min	I_R nA Max @	V_R V	V_F V Min	V_F V Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
BAY74	DO-35	50	100	35	0.54	0.65	1.0	3.0	4.0	(Note 5)	D4
					0.65	0.77	10.0				
					0.73	0.88	50.0				
					0.78	0.93	100.0				
					0.82	1.0	200.0				
					0.85	1.10	300.0				
BAY82	DO-7	15	100	12	0.41	0.53	0.010	1.3	0.75	(Note 2)	D3
					0.53	0.66	0.1				
					0.64	0.79	1.0				
					0.77	0.94	10				
					0.80	1.00	20				
					0.90	1.35	50				
FD700	DO-7	30	50	20	0.42	0.50	0.01	1.0	0.70	(Note 2)	D3
					0.52	0.61	0.1				
					0.64	0.74	1.0				
					0.76	0.88	10				
					0.81	0.95	20				
					0.89	1.10	50				
FD777	DO-7	15	100	8	0.42	0.53	0.01	1.3	0.75	(Note 2)	D3
					0.52	0.64	0.1				
					0.64	0.79	1.0				
					0.76	0.94	10				
					0.81	1.00	20				
					0.89	1.35	50				

Note 1: I_F = 10 mA, V_R = 6V, R_L = 100Ω, Recovery to 1.0 mA.

Note 2: I_F = I_R = 10 mA, R_L = 100Ω.

Note 3: I_F = 10 mA, I_R = 1 mA, V_R = 6V, R_L = 100Ω.

Note 4: I_F = 10 mA, I_R = 6 mA, V_R = 6V, R_L = 100Ω, Recovery to 1 mA.

Note 5: I_F = 10 mA to 200 mA, Recovery to 100% of I_F.

Device No.	Package No.	V_{RRM} V Min	I_R nA Max @	V_R V	V_F V Min	V_F V Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
FDH600	DO-35	75	100	50		0.65	1.0	2.5	4.0	(Note 2)	D4
						0.79	10				
						0.86	50				
						0.92	100				
						1.0	200				
FDH666	DO-35	40	100	25		0.65	1.0	3.5	4.0	(Note 1)	D4
						0.79	10.0				
						0.86	50.0				
						1.0	100.0				
FDH900	DO-35	45	500	40		1.0	100.0	3.0	4.0	(Note 2)	D4
FDH999	DO-35	35	1000	25		1.0	10.0	5.0	5.0	(Note 2)	D4

Note 1: I_F = I_R = 10 mA, R_L = 100Ω, Recovery to 0.1 I_R.

Note 2: I_F = 10 mA, I_R = 10 mA, R_L = 100Ω, I_{rr} = 1.0 mA.

Low Leakage Diodes (Glass Package)

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@	V_R V	V_F V		@	I_F mA	C pF Max	Proc No.
						Min	Max				
1N456	DO-35	30	25		25		1.0		40	10	D2
1N456A	DO-35	30	25		25		1.0		100		D2
1N457	DO-35	70	25		60		1.0		20	8.0	D2
1N457A	DO-35	70	25		60		1.0		100		D2
1N458	DO-35	150	25		125		1.0		7	6.0	D2
1N458A	DO-35	150	25		125		1.0		100		D2
1N459	DO-35	200	25		175		1.0		3	6	D2
1N459A	DO-35	200	25		175		1.0		100		D2
1N482B	DO-35	40	25		36		1.0		100		D2
1N483B	DO-35	80	25		70		1.0		100		D2
1N484B	DO-35	150	25		130		1.0		100		D2
1N485B	DO-35	200	25		180		1.0		100		D2
1N486B	DO-35	250	50		225		1.0		100		D2
1N3595	DO-35	150	1.0		125	See 1N6099				8.0	D2
1N6099	DO-35	150	1.0		125	0.52	0.68		1.0	8.0	D2
						0.60	0.75		5.0		
						0.65	0.80		10.0		
						0.75	0.88		50.0		
						0.79	0.92		100.0		
						0.83	1.0		200.0		
BAY73	DO-35	125	5		100	0.60	0.68		1.0	8.0	D2
						0.67	0.75		5.0		
						0.69	0.80		10.0		
						0.78	0.88		50.0		
						0.81	0.94		100.0		
						0.85	1.00		200.0		
BA129	DO-35	200	10		180	0.51	0.60		0.1	6.0	D2
						0.60	0.71		1.0		
						0.69	0.83		10		
						0.78	1.00		100		
FDH300	DO-35	150	1.0		125		0.68		1.0	6.0	D2
							0.75		5.0		
							0.8		10.0		
							0.88		50.0		
							0.92		100.0		
							1.0		200.0		
FDH333	DO-35	150	3.0		125	0.80	0.89		50	6.0	D2
						0.83	0.94		100		
						0.86	0.97		150		
						0.87	1.05		200		
						0.88	1.08		250		
						0.90	1.15		300		
FJT1100	DO-7	30	0.001		5.0		1.05		50	1.5	D6
			0.010		15.0						
FJT1101	DO-7	20	0.005		5.0		1.10		50	1.8	D6
			0.015		15.0						

High Voltage Diodes (Glass Package)

Device No.	Package No.	V_{RRM} V Min	I_R nA Max @	V_R V	V_F V Min	V_F V Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N625	DO-35	30	1000	20		1.5	4.0		1000	(Note 1)	D1
1N626	DO-35	50	1000	35		1.5	4.0		1000	(Note 1)	D1
1N627	DO-35	100	1000	75		1.5	4.0		1000	(Note 1)	D1
1N628	DO-35	150	1000	125		1.5	4.0		1000	(Note 1)	D1
1N629	DO-35	200	1000	175		1.5	4.0		1000	(Note 1)	D1
1N658	DO-35	120	50	50		1.0	100		300	(Note 2)	D1
1N659	DO-35	60	5000	50		1.0	6.0		300	(Note 2)	D1
1N660	DO-35	120	5000	100		1.0	6		300	(Note 3)	D1
1N661	DO-35	240	10000	200		1.0	6		300	(Note 3)	D1

Note 1: I_F = 30 mA, V_R = 35V, Recovery to 400 kΩ.

Note 2: V_R = 40V, I_F = 5.0 mA, R_L = 2.0 kΩ, C_L = 10 pF, Recovery to 80 kΩ.

Note 3: V_R = 35V, I_F = 30 mA, R_L = 2.0 kΩ, C_L = 10 pF, Recovery to 400 kΩ.

Device No.	Package No.	V_{RRM} V Min	I_R nA Max @	V_R V	V_F V Min	V_F V Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N3070	DO-35	200	100	175		1.0	100	5.0	50	(Note 1)	D1
1N4938	DO-35	200	100	175		1.0	100	5.0	50	(Note 1)	D1
BAV19	DO-35	120	100	100		1.0	100	5.0	50	(Note 2)	D1
BAV20	DO-35	200	100	150		1.0	100	5.0	50	(Note 2)	D1
BAV21	DO-35	250	100	200		1.0	100	5.0	50	(Note 2)	D1
BAX17	DO-35	200				1.2	200	10	120	(Note 2)	D1
BAY72	DO-35	125	100	100	0.51	0.64	1.0	5.0	50	(Note 3)	D1
					0.63	0.78	10.0				
					0.73	0.92	50.0				
					0.78	1.0	100.0				
BAY80	DO-35	150	100	120		1.0	150	6.0	60	(Note 3)	D1
FDH400	DO-35	200	100	150		1.1	300	2.0	50	(Note 4)	D1
FDH444	DO-35	150	50	100		1.2	300	2.5	60	(Note 4)	D1

Note 1: I_F = I_R = 30 mA, R_L = 100Ω.

Note 2: I_F = 30 mA, I_R = 30 mA, R_L = 100Ω, Recovery to I_R = 3 mA.

Note 3: I_F = I_R = 30 mA, R_L = 75Ω.

Note 4: I_F = 30 mA, R_L = 100Ω, I_{rr} = 3.0 mA.

General Purpose Diodes (Glass Package)

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Min	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N461A	DO-35	30	500	25		1.0	100				D2
1N462A	DO-35	70	500	60		1.0	100				D2
1N463A	DO-35	200	500	175		1.0	100				D2
1N659	DO-35	60	5000	50		1.0	6.0		300	(Note 1)	D4
1N660	DO-35	120	5000	100		1.0	6.0		300	(Note 1)	D1
1N661	DO-35	240	10000	200		1.0	6.0		300	(Note 1)	D1
1S44	DO-35	50	50	10	0.65 0.70	1.0 1.2	10 30	4.0	8	(Note 2)	D4
1S920	DO-35	50	100	50		1.2	200	6.5			D1
1S921	DO-35	100	100	100		1.2	200	6.5			D1
1S922	DO-35	150	100	150		1.2	200	6.5			D1
1S923	DO-35	200	100	200		1.2	200	6.5			D1
BA128	DO-35	75	100	50	0.40 0.51 0.63 0.73	0.52 0.64 0.79 1.00	0.1 1.0 10 50	5.0			D4
BA130	DO-35	30	100	25	0.34 0.45 0.56 0.69	0.47 0.58 0.71 1.00	0.01 0.1 1.0 10	2.0			D4
BA217	DO-35	30	200	30		1.5	50	3.0	4.0	(Note 5)	D4
BA218	DO-35	50	200	50		1.5	50	3.0	4.0	(Note 5)	D4
BA317	DO-35	30				0.85	10	2.0	4.0	(Note 4)	D4
BA318	DO-35	50				0.85	10	2.0	4.0	(Note 4)	D4
BAV17	DO-35	25	100	20		1.0	100	5.0	50	(Note 3)	D4
BAV18	DO-35	60	100	50		1.0	100	5.0	50	(Note 3)	D4
BAX16	DO-35	180	100	150		1.5	200	10	120	(Note 3)	D1
FDH900	DO-35	45	500	40		1.0	100	3.0	4.0	(Note 4)	D4
FDH999	DO-35	35	1000	25		1.0	10	5.0	5.0	(Note 4)	D4
FDH1000	DO-35	75	5000	50		1.0	500	5.0			D4

Note 1: V_R = 35V, I_F = 30 mA, R_L = 2.0 kΩ, C_L = 10 pF, Recovery to 400 kΩ.

Note 2: I_F = I_r = 10 mA, Recovery to 1 mA.

Note 3: I_F = 30 mA, I_R = 30 mA, R_L = 100Ω.

Note 4: I_F = 10 mA, I_R = 10 mA, R_L = 100Ω, I_{rr} = 1.0 mA.

Note 5: I_f = 10 mA, I_R = 60 mA; R_L = 100Ω; Recovery to 1 mA.

Note 6: I_F = 10 mA; I_R = 60 mA; R_L = 100Ω.

Military Qualified Diodes

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Proc. No.
1N457JAN	DO-35	70	25	60	1.0	20	6.0		D2
1N458JAN	DO-35	150	25	125	1.0	7.0	6.0		D2
1N459JAN	DO-35	200	25	175	1.0	3.0	6.0		D2
1N483BJAN	DO-35	80	25	70	1.0	100			D2
1N483BJANTX	DO-35	80	25	70	1.0	100			D2
1N485BJAN	DO-35	200	25	180	1.0	100			D2
1N485BJANTX	DO-35	200	25	180	1.0	100			D2
1N486BJAN	DO-35	250	25	225	1.0	100			D2
1N486BJANTX	DO-35	250	25	225	1.0	100			D2
1N914JAN	DO-35	100	25	20	1.0	10	4.0	4.0	D4
1N914JANTX	DO-35	100	25	20	1.0	10	4.0	4.0	D4
1N3064JAN	DO-7	75	100	50	1.0	10	2.0	4.0	D4
1N3064JANTX	DO-7	75	100	50	1.0	10	2.0	4.0	D4
1N3595JAN	DO-7	150	1.0	125	1.0	200	8.0	3000	D2
1N3595JANTX	DO-7	150	1.0	125	1.0	200	8.0	3000	D2
1N3595JANTXV	DO-7	150	1.0	125	1.0	200	8.0	3000	D2
1N3600JAN	DO-7	75	100	50	1.0	200	2.5	4.0	D4
1N3600JANTX	DO-7	75	100	50	1.0	200	2.5	4.0	D4
1N3600JANTXV	DO-7	75	100	50	1.0	200	2.5	4.0	D4
1N4148-1JAN	DO-35	100	25	20	1.0	10	4.0	4.0	D4
1N4148-1JANTX	DO-35	100	25	20	1.0	10	4.0	4.0	D4
1N4148-1JANTXV	DO-35	100	25	20	1.0	10	4.0	4.0	D4
1N4150-1JAN	DO-35	75	100	50	1.0	200	2.5	4.0	D4
1N4150-1JANTX	DO-35	75	100	50	1.0	200	2.5	4.0	D4
1N4150-1JANTXV	DO-35	75	100	50	1.0	200	2.5	4.0	D4
1N4376JAN	DO-7	20	100	10	1.1	50	1.0	0.75	D3
1N4376JANTX	DO-7	20	100	10	1.1	50	1.0	0.75	D3
1N4454-1JAN	DO-35	75	100	50	1.0	10	2.0	4.0	D4
1N4454-1JANTX	DO-35	75	100	50	1.0	10	2.0	4.0	D4
1N4454-1JANTXV	DO-35	75	100	50	1.0	10	2.0	4.0	D4
1N3070JAN	DO-35	200	100	175	1.0	100	5.0	50	D1
1N3070JANTX	DO-35	200	100	175	1.0	100	5.0	50	D1
1N4306JAN	DO-7	75	50	50	1.0	50	2.0	4.0	D4
1N4306JANTX	DO-7	75	50	50	1.0	50	2.0	4.0	D4
1N4306JANTXV	DO-7	75	50	50	1.0	50	2.0	4.0	D4
1N4307JAN	DO-7	75	50	50	1.0	50	2.0	4.0	D4
1N4307JANTX	DO-7	75	50	50	1.0	50	2.0	4.0	D4
1N4307JANTXV	DO-7	75	50	50	1.0	50	2.0	4.0	D4

Military Qualified Diode Arrays (Ceramic Package) (Note 1)

Device No.	Package No.	Configuration	V_{RRM} V Min	V_F V Max	@	I_F mA	t_{fr} ns Max	t_{rr} ns Max	C pF Max
1N5768JAN	TO-85	CC8	60	1.0		100	40	20	4.0
1N5768JANTX	TO-85	CC8	60	1.0		100	40	20	4.0
1N5768JANTXV	TO-85	CC8	60	1.0		100	40	20	4.0
1N5770JAN	TO-85	CA8	60	1.0		100	40	20	8.0
1N5770JANTX	TO-85	CA8	60	1.0		100	40	20	8.0
1N5770JANTXV	TO-85	CA8	60	1.0		100	40	20	8.0
1N5772JAN	TO-85	M16N	60	1.0		100	40	20	8.0
1N5772JANTX	TO-85	M16N	60	1.0		100	40	20	8.0
1N5772JANTXV	TO-85	M16N	60	1.0		100	40	20	8.0
1N5774JAN	TO-86	2M8	60	1.0		100	40	20	8.0
1N5774JANTX	TO-86	2M8	60	1.0		100	40	20	8.0
1N5774JANTXV	TO-86	2M8	60	1.0		100	40	20	8.0
1N6100JAN	TO-86	S7	75	1.0		100	15	5.0	3.0
1N6100JANTX	TO-86	S7	75	1.0		100	15	5.0	3.0
1N6100JANTXV	TO-86	S7	75	1.0		100	15	5.0	3.0
1N6101JAN	6B	S8	75	1.0		100	15	5.0	3.0
1N6101JANTX	6B	S8	75	1.0		100	15	5.0	3.0
1N6101JANTXV	6B	S8	75	1.0		100	15	5.0	3.0

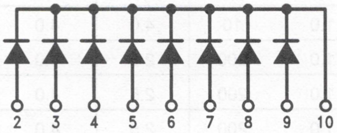
Note 1: Refer to Process 15 for product family characteristics.

Note 2: t_{fr} test conditions: $I_f = 500$ mA; $R_s = 10\Omega$; $V_{fr} = 1.8V$, $t_r = 15$ ns Max.

Note 3: Capacitance is measured pin-to-pin across each diode and does not necessarily represent actual diode capacitance since other diode interconnections can contribute additional capacitance.

Configurations

CC8



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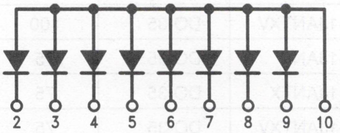

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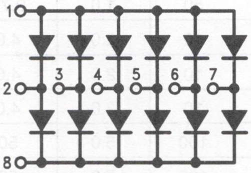

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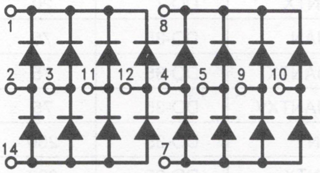

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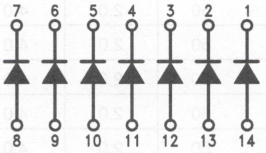

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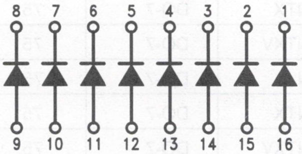


TL/G/10019-18

Monolithic Diode Arrays (Plastic-Ceramic-Metal Packages)

Device No.	Package No.	Configuration	V_{RRM} V Min	V_F V Max	@ I_F mA	ΔV_F mV Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N5768	TO-85	CC8	60	1.0	100		20	(Note 1)	D15
1N5770	TO-85	CA8	60	1.0	100		20	(Note 1)	D15
1N5772	TO-85	M16N	60	1.0	100		20	(Note 1)	D15
1N5774	TO-86	2M8	60	1.0	100		20	(Note 1)	D15
1N6100	TO-86	S8	75	1.0	100		5	(Note 2)	D15
1N6101	TO-116-2	S8	75	1.0	100		5	(Note 2)	D15
1N6496	20 Lead Cerpak	2M16	60	1.0	200		10	(Note 3)	D15
				1.2	250				
				1.5	500				
FSA2002	TO-85	CC8	60	1.0	100		10	(Note 3)	D15
				1.1	200				
				1.5	500				
FSA2003	TO-85	CA8	60	1.0	100		10	(Note 3)	D15
				1.1	200				
				1.5	500				
FSA2500M	TO-85	M16	60	1.0	100	15	10	(Note 3)	D15
				1.1	200				
				1.5	500				
FSA2501M	TO-116-2	M16S	60	1.0	100	15	10	(Note 3)	D15
				1.1	200				
				1.5	500				
FSA2501P	TO-116	M16S	60	See FSA2500M		15	10	(Note 3)	D15
FSA2503M	TO-116-2	2M8	60	1.0	100	15	10	(Note 3)	D15
				1.1	200				
				1.5	500				
FSA2503P	TO-116	2M8	60	1.0	100	15	10	(Note 3)	D15
				1.1	200				
				1.5	500				
FSA2504M	TO-86	2M8	60	See FSA2503M		15	10	(Note 3)	D15
FSA2508P	9B	2M8	60	See FSA2509M		15	10	(Note 3)	D15
FSA2509M	TO-116-2	2M8	60	1.0	100	15	10	(Note 3)	D15
				1.1	200				
				1.3	500				
FSA2509P	TO-116	2M8	60	1.0	100	15	10	(Note 3)	D15
				1.1	200				
				1.3	500				

Monolithic Diode Arrays (Plastic - Ceramic - Metal Packages) (Continued)

Device No.	Package No.	Configuration	V_{RRM} V Min	V_F V Max	@	I_F mA	ΔV_F mV Max	t_{rr} ns Max	Test Cond.	Proc. No.
FSA2510M	TO-116-2	M16S	60	See FSA2509			15	10	(Note 3)	D15
FSA2510P	TO-116	M16S	60	See FSA2509			15	10	(Note 3)	D15
FSA2563M	TO-116-2	CC8S	60	1.0 1.1 1.3		100 200 500	15	10	(Note 3)	D15
FSA2563P	TO-116	CC8S	60	1.0 1.1 1.3		100 200 500	15	10	(Note 3)	D15
FSA2564M	TO-116-2	CA8S	60	See FSA2563			15	10	(Note 3)	D15
FSA2564P	TO-116	CA8S	60	See FSA2563			15	10	(Note 3)	D15
FSA2565M	TO-116-2	CC13	60	See FSA2563			15	10	(Note 3)	D15
FSA2565P	TO-116	CC13	60	See FSA2563			15	10	(Note 3)	D15
FSA2566M	TO-116-2	CA13	60	See FSA2563			15	10	(Note 3)	D15
FSA2566P	TO-116	CA13	60	See FSA2563			15	10	(Note 3)	D15

Note 1: $I_F = 200$ mA, $I_R = 200$ mA, $R_L = 100\Omega$, $I_{rr} = 20$ mA.

Note 2: $I_F = I_R = 10$ mA, $I_{rr} = 1.0$ mA, $R_L = 100\Omega$.

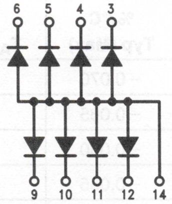
Note 3: $I_F = I_R = 100$ mA, $R_L = 100\Omega$, Recovery to 0.1 I_R.

Device No.	Package No.	Configuration	V_{RRM} V Min	V_F V Max	@	I_F mA	ΔV_F mV Max	t_{rr} ns Max	Test Cond.	Proc. No.
FSA2619M	6B	S8	100	1.0		10	15	5	(Note 1)	D15
FSA2619P	9B	S8	100	1.0		10	15	5	(Note 1)	D15
FSA2620M	TO-116-2	S7	100	1.0		10	15	5	(Note 1)	D15
FSA2620P	TO-116	S7	100	1.0		10	15	5	(Note 1)	D15
FSA2621M	TO-86	S7	100	1.0		10	15	5	(Note 1)	D15
FSA2621M	TO-116	S7	100	1.0		10	15	5	(Note 1)	D15
FSA2719M	6B	S8	75	1.0		10	15	6	(Note 1)	D15
FSA2719P	9B	S8	75	1.0		10	15	6	(Note 1)	D15
FSA2720M	TO-116-2	S7	75	1.0		10	15	6	(Note 1)	D15
FSA2720P	TO-116	S7	75	1.0		10	15	6	(Note 1)	D15
FSA2721M	TO-86	S7	75	1.0		10	15	6	(Note 1)	D15

Note 1: $I_F = I_R = 10$ mA, $I_{rr} = 1.0$ mA.

Configurations

CA8S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TL/G/10019-7

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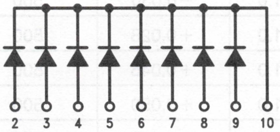
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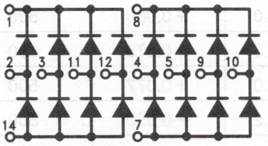
TL/G/10019-8

2M8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TL/G/10019-10

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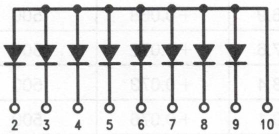
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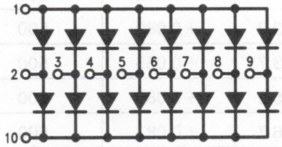
TL/G/10019-11

M16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TL/G/10019-12

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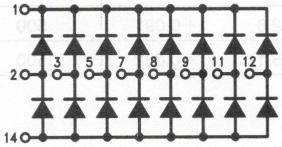
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TL/G/10019-13

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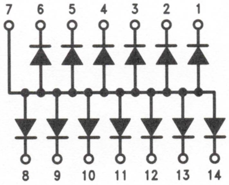
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TL/G/10019-14

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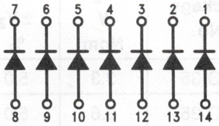
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TL/G/10019-15

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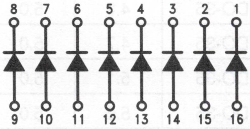
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TL/G/10019-16

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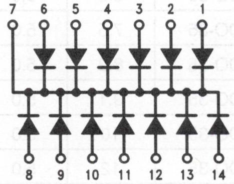
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TL/G/10019-17

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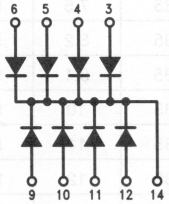
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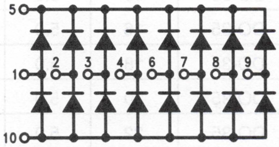
TL/G/10019-19

M16M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TL/G/10019-21

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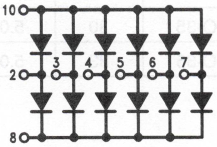

TL/G/10019-20

Zener Diodes (Glass Package)

Device No.	Package No.	V_Z V Nom	Tol. $\pm V_Z$ %	Z_Z Ω Max @	I_Z mA	I_R µA Max @	V_R V	T.C. %/°C Typ (Max)	P_D mW $T_A = 25°C$	Proc. No.
1N746A	DO-35	3.3	5.0	28.0	20	10	1.0	−0.070	500	D13
1N747A	DO-35	3.6	5.0	24.0	20	10	1.0	−0.065	500	D13
1N748A	DO-35	3.9	5.0	23.0	20	10	1.0	−0.060	500	D13
1N749A	DO-35	4.3	5.0	22.0	20	2	1.0	−0.055	500	D13
1N750A	DO-35	4.7	5.0	19.0	20	2	1.0	−0.043	500	D13
1N751A	DO-35	5.1	5.0	17.0	20	1	1.0	−0.030	500	D13
1N752A	DO-35	5.6	5.0	11	20	1.0	1.0	+0.028	500	D13
1N753A	DO-35	6.2	5.0	7.0	20	0.1	1.0	+0.045	500	D13
1N754A	DO-35	6.8	5.0	5.0	20	0.1	1.0	+0.050	500	D13
1N755A	DO-35	7.5	5.0	6.0	20	0.1	1.0	+0.058	500	D13
1N756A	DO-35	8.2	5.0	8.0	20	0.1	1.0	+0.062	500	D13
1N757A	DO-35	9.1	5.0	10	20	0.1	1.0	+0.068	500	D13
1N758A	DO-35	10	5.0	17	20	0.1	1.0	+0.075	500	D13
1N759A	DO-35	12	5.0	30	20	0.1	1.0	+0.077	500	D13
1N957B	DO-35	6.8	5.0	4.5	18.5	150	5.2	+0.050	500	D13
1N958B	DO-35	7.5	5.0	5.5	16.5	75	5.7	+0.058	500	D13
1N959B	DO-35	8.2	5.0	6.5	15	50	6.2	+0.062	500	D13
1N960B	DO-35	9.1	5.0	7.5	14	25	6.9	+0.068	500	D13
1N961B	DO-35	10	5.0	8.5	12.5	10	7.6	+0.072	500	D13
1N962B	DO-35	11	5.0	9.5	11.5	5.0	8.4	+0.073	500	D13
1N963B	DO-35	12	5.0	11.5	10.5	5.0	9.1	+0.076	500	D13
1N964B	DO-35	13	5.0	13	9.5	5.0	9.9	+0.079	500	D13
1N965B	DO-35	15	5.0	16	8.5	5.0	11.4	+0.082	500	D13
1N966B	DO-35	16	5.0	17	7.8	5.0	12.2	+0.083	500	D13
1N967B	DO-35	18	5.0	21	7.0	5.0	13.7	+0.085	500	D13
1N968B	DO-35	20	5.0	25	6.2	5.0	15.2	+0.086	500	D13
1N969B	DO-35	22	5.0	29	5.6	5.0	16.7	+0.087	500	D13
1N970B	DO-35	24	5.0	33	5.2	5.0	18.2	+0.088	500	D13
1N971B	DO-35	27	5.0	41	4.6	5.0	20.6	+0.090	500	D13
1N972B	DO-35	30	5.0	49	4.2	5.0	22.8	+0.091	500	D13
1N973B	DO-35	33	5.0	58	3.8	5.0	25.1	+0.092	500	D13

Zener Diodes (Glass Package) (Continued)

Device No.	Package No.	V_Z V Nom	Tol. $\pm V_Z$ %	Z_Z Ω Max	@	I_Z mA	I_R µA Max	@	V_R V	T.C. %/°C Typ (Max)	P_D mW $T_A = 25°C$	Proc. No.
1N4728A	DO-41	3.3	5.0	10		76	100		1.0		1000	D14
1N4729A	DO-41	3.6	5.0	10		69	100		1.0		1000	D14
1N4730A	DO-41	3.9	5.0	9		64	50		1.0		1000	D14
1N4731A	DO-41	4.3	5.0	9		58	10		1.0		1000	D14
1N4732A	DO-41	4.7	5.0	8		53	10		1.0		1000	D14
1N4733A	DO-41	5.1	5.0	7		49	10		1.0		1000	D14
1N4734A	DO-41	5.6	5.0	5		45	10		2.0		1000	D14
1N4735A	DO-41	6.2	5.0	2		41	10		3.0		1000	D14
1N4736A	DO-41	6.8	5.0	3.5		37	10		4.0		1000	D14
1N4737A	DO-41	7.5	5.0	4		34	10		5.0		1000	D14
1N4738A	DO-41	8.2	5.0	4.5		34	10		6.0		1000	D14
1N4739A	DO-41	9.1	5.0	5		8	10		7.0		1000	D14
1N4740A	DO-41	10	5.0	7		25	10		7.6		1000	D14
1N4741A	DO-41	11	5.0	8		23	5		8.4		1000	D14
1N4742A	DO-41	12	5.0	9		21	5		9.1		1000	D14
1N4743A	DO-41	13	5.0	10		19	5		9.9		1000	D14
1N4744A	DO-41	15	5.0	14		17	5		11.4		1000	D14
1N4745A	DO-41	16	5.0	16		15.5	5		12.2		1000	D14
1N4746A	DO-41	18	5.0	20		14	5		13.7		1000	D14
1N4747A	DO-41	20	5.0	22		12.5	5		15.2		1000	D14
1N4748A	DO-41	22	5.0	23		11.5	5		16.7		1000	D14
1N4749A	DO-41	24	5.0	25		10.5	5		18.2		1000	D14
1N4750A	DO-41	27	5.0	35		9.5	5		20.6		1000	D14
1N4751A	DO-41	30	5.0	40		8.5	5		22.8		1000	D14
1N4752A	DO-41	33	5.0	45		7.5	5		25.1		1000	D14
1N5226B	DO-35	3.3	5.0	28		20	25		1.0	(−0.070)	500	D13
1N5227B	DO-35	3.6	5.0	24		20	15		1.0	(−0.065)	500	D13

Zener Diodes (Glass Package) (Continued)

Device No.	Package No.	V_Z V Nom	Tol. $\pm V_Z$ %	Z_Z Ω Max	@ I_Z mA	I_R µA Max	@ V_R V	T.C. %/°C Typ (Max)	P_D mW $T_A = 25°C$	Proc. No.
1N5228B	DO-35	3.9	5.0	23	20	10	1.0	(−0.060)	500	D13
1N5229B	DO-35	4.3	5.0	22	20	5	1.0	(±0.055)	500	D13
1N5230B	DO-35	4.7	5.0	19	20	5	2.0	(±0.030)	500	D13
1N5231B	DO-35	5.1	5.0	17	20	5	2.0	(±0.030)	500	D13
1N5232B	DO-35	5.6	5.0	11	20	5	3.0	(±0.038)	500	D13
1N5233B	DO-35	6.0	5.0	7	20	5	3.5	(±0.038)	500	D13
1N5234B	DO-35	6.2	5.0	7	20	5	4.0	(±0.045)	500	D13
1N5235B	DO-35	6.8	5.0	5	20	3	5.0	(+0.050)	500	D13
1N5236B	DO-35	7.5	5.0	6	20	3	6.0	(+0.058)	500	D13
1N5237B	DO-35	8.2	5.0	8	20	3	6.5	(+0.062)	500	D13
1N5238B	DO-35	8.7	5.0	8	20	3	6.5	(+0.065)	500	D13
1N5239B	DO-35	9.1	5.0	10	20	3	7.0	(+0.068)	500	D13
1N5240B	DO-35	10.0	5.0	1.7	20	3	8.0	(+0.075)	500	D13
1N5241B	DO-35	11	5.0	22	20	2	8.4	(+0.076)	500	D13
1N5242B	DO-35	12	5.0	30	20	1	9.1	(+0.077)	500	D13
1N5243B	DO-35	13	5.0	13	9.5	0.5	9.9	(+0.079)	500	D13
1N5244B	DO-35	14	5.0	15	9.0	0.1	11.0	(+0.082)	500	D13
1N5245B	DO-35	15	5.0	16	8.5	0.1	11.4	(+0.082)	500	D13
1N5246B	DO-35	16	5.0	17	7.8	0.1	12.0	(+0.083)	500	D13
1N5247B	DO-35	17	5.0	19	7.4	0.1	13.0	(+0.084)	500	D13
1N5248B	DO-35	18	5.0	21	7.0	0.1	14.0	(+0.085)	500	D13
1N5249B	DO-35	19	5.0	23	6.6	0.1	14.0	(+0.086)	500	D13
1N5250B	DO-35	20	5.0	25	6.2	0.1	15.0	(+0.086)	500	D13
1N5251B	DO-35	22	5.0	29	5.6	0.1	17.0	(+0.087)	500	D13
1N5252B	DO-35	24	5.0	33	5.2	0.1	18.0	(+0.088)	500	D13
1N5253B	DO-35	25	5.0	5	5.0	0.1	19.0	(+0.089)	500	D13
1N5254B	DO-35	27	5.0	41	4.6	0.1	21.0	(+0.090)	500	D13
1N5255B	DO-35	28	5.0	44	4.5	0.1	21.0	(+0.091)	500	D13
1N5256B	DO-35	30	5.0	49	4.2	0.1	23.0	(+0.091)	500	D13
1N5257B	DO-35	33	5.0	58	3.8	0.1	25.0	(+0.092)	500	D13

Pair & Quad Assemblies Diodes

Device No.	Package No.	V_{RRM} V Min	I_R nA Max	@ V_R V	V_F V Min	V_F V Max	@ I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. No.
1N4306	DO-7	75	50	50	0.44	0.55	0.1	2	4	(Note 1)	D4*
1N4307	DO-7	75	50	50	0.56	0.67	1.0				D4*
					0.67	0.81	10.0				
					0.75	1.00	50.0				

Note 1: $I_F = I_R = 10$ mA, $R_L = 100\Omega$, Recovery to 1 mA.

*For test circuits, refer to Process Family Characteristics D18.

FA Series

Matched Pair and Quad Assemblies Diodes **PACKAGE All Devices DO-7**

MATCHING CHARACTERISTICS Apply over temperature range of −55°C to +100°C

Basic Diode (See Specification Below)	Forward Current Matching Range (Notes 4 & 6)	Reverse Current Match (ΔI_R Maximum) (Note 3)	Forward Voltage Match (ΔV_F Maximum)	Assembly Type Number	
				Pair	Quad
FD1389	10 µA to 1.0 mA		3.0 mV	FA2310U	FA4310U
FD1389	10 µA to 1.0 mA		10 mV	FA2311U	FA4311U
FD1389	1.0 mA to 10 mA		5.0 mV	FA2312U	FA4312U
FD1389	1.0 mA to 10 mA		15 mV	FA2313U	FA4313U
FD2389	10 µA to 1.0 mA		3.0 mV	FA2320U	FA4320U
FD2389	10 µA to 1.0 mA		10 mV	FA2321U	FA4321U
FD2389	1.0 mA to 10 mA		5.0 mV	FA2322U	FA4322U
FD2389	1.0 mA to 10 mA		15 mV	FA2323U	FA4323U
FD2389	10 mA to 100 mA		10 mV	FA2324U	FA4324U
FD2389	10 mA to 100 mA		20 mV	FA2325U	FA4325U
FD3389	10 µA to 1.0 mA	$(2.0 + 0.064\ V_R)$ nA	10 mV	FA2330U	FA4330U
FD3389	1.0 mA to 10 mA	$(2.0 + 0.064\ V_R)$ nA	15 mV	FA2331U	FA4331U
FD3389	10 mA to 100 mA	$(2.0 + 0.064\ V_R)$ nA	20 mV	FA2332U	FA4332U
FD3389	10 µA to 1.0 mA	$(4.0 + 0.128\ V_R)$ nA	10 mV	FA2333U	FA4333U
FD3389	1.0 mA to 10 mA	$(4.0 + 0.128\ V_R)$ nA	15 mV	FA3334U	FA4334U
FD3389	10 mA to 100 mA	$(4.0 + 0.128\ V_R)$ nA	20 mV	FA2335U	FA4335U
FD6389	10 mA to 100 mA		10 mV	FA2360U	FA4360U
FD6389	10 mA to 100 mA		20 mV	FA2361U	FA4361U

BASIC DIODE ELECTRICAL CHARACTERISTICS 25°C Ambient Temperature unless otherwise noted

Symbol	Parameter	Test Conditions	FD1389		FD2389		FD3389		FD6389		Units
			Min	Max	Min	Max	Min	Max	Min	Max	
V_{RRM}	Breakdown Voltage	$I_R = 5.0\ \mu A$	100								V
		$I_R = 100\ \mu A$			200		150		75		V
I_R	Reverse Current	V_R = WIV		100		100		1.0		100	nA
		V_R = WIV, T_A = 150°C		100		100		3.0		100	µA
V_F	Forward Voltage	$I_F = 200$ mA				1.000		1.000		1.000	V
		$I_F = 100$ mA				0.925		0.930		0.920	V
		$I_F = 50$ mA				0.860		0.880		0.880	V
		$I_F = 20$ mA		1.000		0.790		0.840		0.790	V
		$I_F = 10$ mA		0.875		0.740		0.810		0.750	V
		$I_F = 5.0$ mA		0.800		0.700		0.770		0.710	V
		$I_F = 2.0$ mA		0.725		0.620		0.730		0.670	V
		$I_F = 1.0$ mA		0.670		0.610		0.710		0.630	V
C	Capacitance (Note 5)	$V_R = 0$, f = 1 MHz		2.0		5.0		6.0		3.0	pF
t_{rr}	Reverse Recovery Time	$I_F = I_R = 10$ mA Recover to 1.0 mA		4.0							ns
		$I_F = I_R = 30$ mA Recover to 1.0 mA				50					ns
		$I_F = I_R = 200$ mA Recover to 20 mA								4.0	ns

Note 1: These are Limiting values above which life or satisfactory performance may be impaired.

Note 2: These are steady state Limits. The factory should be consulted on applications involving pulsed or low duty-cycle operation.

Note 3: The Reverse Current Match (ΔI_R) is the difference in reverse current between the diode having the highest I_R and that having the lowest I_R in a given assembly. The reverse voltage (V_R) in the ΔI_R calculation can be any value up to 125V. For example, the maximum ΔI_R for an FA2330U at V_R of IO V is (2.0 + 0.064 × 10) nA or 2.64 nA.

Note 4: The Forward Current Matching Ranges between 10 µA and 10 mA may be applied either as a dc current or a pulse current. Above 10 mA, however, the matching characteristics are guaranteed only for low duty cycle (≤1%) pulse current. Conditions of test are shown in the characteristic curve and test circuit section of this book.

Note 5: For product family characteristics curves for the basic diodes used in the assemblies, refer to the following:
FD1389 D4, FD2389 D1, FD3389 D2 and FD6389 D4.

Section 3
Bipolar NPN Transistors

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National Semiconductor

Saturated Switches

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N2369	TO-18 (11)	40	15	4.5	400	20	20 40	 120	100 10	2 1	0.25	0.7	0.85	10	4	500		10	18	(Note 1)	21
2N2369A also Avail. JAN/TX/V Versions	TO-18 (11)	40	15	4.5	400*	20	20 30 40 40	120 120 120 120	100 30 10 10	1 0.4 1 0.35	0.2 0.25 0.6	0.7	0.85 1.5 1.6	10 30 100	4	500		10	18	(Note 1)	21
2N3011	TO-18 (11)	30	12	5	400*	20	12 25 30	 120	100 30 10	1 0.4 0.35	0.2 0.25 0.5	0.72	0.85 1.5 1.6	10 30 100	4	400		20	20	(Note 4)	21
2N3605	TO-92 (94)		14		500	18	30		10	1	0.25		0.85	10	6	300		10	45	(Note 2)	21
2N3606	TO-92 (94)		14		500	18	30		10	1	0.25		0.85	10	6	300		10	60	(Note 2)	21
2N3607	TO-92 (94)		14		500	18	30		10	1	0.25		0.85	10	6	300		10	70	(Note 2)	21
2N4274		Same as PN4274																			21
2N4275		Same as PN4275																			21
2N4294	TO-92 (94)	30	12	4.5	400	20	20 30	 120	100 10	2 1	0.25	0.6	0.9	10	5	400		10	20	(Note 1)	21
2N4295	TO-92 (94)	40	15	5	100	20	20 40	 120	100 10	2 1	0.25	0.6	0.9	10	4	500		10	15	(Note 1)	21
2N5030	TO-92 (94)	30	12	4	250	20	30		10	1	0.25	0.72	0.87	10	4	400		10	30	(Note 9)	21
2N5134		Same as PN5134																			21

Saturated Switches (Continued)

Type No.	Case Style	V_{CES}^* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N5224	TO-92	25	12	5	500	15	15		100	1	0.35		0.9	10	4	250		10	60	(Note 11)	21
	(92)						40	100	10	1											
2N5769	TO-92	40	15	4.5	400	20	20		100	1	0.2	0.7	0.85	10	4	500		10	18	(Note 1)	21
	(92)						30		30	0.4	0.25		1.5	30							
							40	120	10	0.35	0.5		1.6	100							
2N5772	TO-92	40	15	5	500	20	15		300	1	0.2	0.75	0.95	30	5	350		30	28	(Note 3)	21
	(92)						25		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
MPS706	TO-92	15	15	3	500	15	20		10	1	0.6		0.9	10	6	200		10	75	(Note 11)	21
	(92)																				
MPS706A	TO-92	25	15	5	500	15	20	60	10	1	0.6		0.9	10	6	200		10	75	(Note 1)	21
	(92)						20		3	1											
MPS834	TO-92	40		5	500	20	26		10	1	0.25		0.9	10	4	350		10	30	(Note 2)	21
	(92)										0.4			50							
MPS2369	TO-92	40	15	4.5	400	20	20		100	2	0.25	0.7	0.85	10	4	500		10	18	(Note 7)	21
	(92)						40	120	10	1											
MPS2369A	TO-92	40	15	4.5	400	20	40	120	10	0.35	0.2		0.85	10	4	500		10	18	(Note 2)	21
	(92)						30		30	0.4	0.25										
							20		100	1	0.5										
MPS2713	TO-92	18	15	5	500	18	30	90	2	−4.5	0.3		1.3	50							21
	(92)																				
MPS2714	TO-92	18	15	5	500	18	75	225	2	4.5	0.3	0.6	1.3	50							21
	(92)																				
PN2369	TO-92	40*	15	4.5	400	20	20		100	2	0.25	0.7	0.85	10	4	500		10	18	(Note 1)	21
	(92)						40	120	10	1											
PN2369A	TO-92	40*	15	4.5	30	20	20		100	1	0.2	0.7	0.85	10	4	500		10	18	(Note 1)	21
	(92)						30		30	0.4	0.2		1.15	30							
							40	120	10	1											
							40		10	0.35	0.5		1.6	100							
PN4274	TO-92	30*	12	4.5	500	20	18		100	1	0.2	0.7	0.85	10	4	400		10	12	(Note 12)	21
	(92)						30		30	0.4	0.25		1.15	30							
							35	120	10	1	0.5		1.6	100							

Saturated Switches (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
PN4275	TO-92	40*	15	4.5	500	20	18		100	1	0.2	0.72	0.85	10	4	400		10	12	(Note 12)	21
	(92)						30		30	0.4	0.25		1.15	30							
							35	120	10	1	0.5		1.6	100							
PN5134	TO-92	20*	10	3.5	100	15	15		30	0.4	0.25	0.7	0.9	10	4	250		10	18	(Note 12)	21
	(92)						20	150	10	1											
2N3009	TO-52	40	15	4	500*	20	15		300	1	0.18	0.75	0.95	30	5	350		30	25	(Note 3)	22
							25		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
2N3013	TO-52	40	15	5	300*	20	15		300	1	0.18	0.75	0.95	30	5	350		30	25	(Note 3)	22
							25		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
2N3014	TO-18	40	20	5	300*	20	30	120	30	0.4	0.18		0.8	10	5	350		30	25	(Note 4)	22
							25		10	0.4	0.18		0.95	30							
							25		100	1.0	0.35		1.2	100							
2N3646	Same as PN3646																				22
MPS3646	Same as PN3646																				22
PN3646	TO-92	40*	15	5	500*	20	15		300	1	0.2	0.75	0.95	30	5	350		30	28	(Note 3)	22
	(92)						20		100	0.5	0.28		1.2	100							
							30	120	30	0.4	0.5		1.7	300							
2N3252	TO-39	60	30	5	500	40	25		1A	5	0.3		1.0	150	12	200		50	70	(Note 7)	25
							30	90	500	1	0.5	0.7	1.3	500							
							30		150	1	1.0		1.8	1A							
2N3253	TO-39	75	40	5	500	60	20		750	5	0.35		1.0	150	12	175		50	70	(Note 7)	25
							25	75	375	1	0.6	0.7	1.3	500							
							25		150	1	1.2		1.8	1A							

Saturated Switches (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N3724	TO-39	50	30	6	1.7 µA	40	30		1A	5	0.32		1.1	300		300		50	60	(Note 7)	25
							25		800	2				500	12						
							35		500	1	0.42	0.9	1.2								
							40		300	1	0.65		1.5	800							
							60	150	100	1											
							30		10	1	0.75		1.7	1A							
2N3724A	TO-39	50	30	6	500	40	25		1.5A	5	0.32		1.1	300	12	300		50	50	(Note 8)	25
							30		1A	5				500							
							30		800	2	0.42		1.2								
							35		500	1											
							40		300	1	0.65		1.3	800					60	(Note 7)	
							60	150	100	1											
							30		10	1	0.75		1.4	1A							
2N3725	TO-39	80	50	6	1.7 µA	60	25		1A	5	0.4		1.1	300	10	300		50	60	(Note 7)	25
							20		800	2	0.52	0.9	1.2	500							
							35		500	1											
							40		300	1	0.8		1.5	800							
							60	150	100	1				1A							
							30		10	1	0.95		1.7								
2N3725A	TO-39	80	50	6	500	60	20		1.5A	5	0.4		1.1	300	10			50	50	(Note 8)	25
							25		1A	5											
							25		800	2	0.52		1.2	500							
							35		500	1	0.8		1.3	800							
							40		300	1											
							60	150	100	1	0.9		1.4	1A					60	(Note 7)	
							30		10	1											
2N4047	TO-39	80	50	6	1.7 µA	60	15		1A	5	0.4		1.1	300	10	250		50	60	(Note 7)	25
							15		800	2											
							20		500	1	0.52	0.9	1.2	500							
							30		300	1	0.8		1.5	800							
							40	150	100	1											
							20		10	1	0.95		1.7	1A							

Saturated Switches (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
2N6737	TO-237 (91)	80	45	6	1.7 μA	60	35		500	1	0.52	0.8	1.1	500	10	300		50	60	(Note 7)	25
MPQ3724	TO-116 (39)	50*	36	6	1.7 μA	40	30		1A	5	0.75		1.7	500	12	300		50	60	(Note 7)	25
							35		500	1											
							60	150	100	1	0.45		1.2	1A							
MPQ3725	TO-116 (39)	80*	50	6	1.7 μA	60	25		1A	5	0.95		1.7	500	10	250		50	60	(Note 7)	25
							35		500	1											
							60	150	100	1	0.52		1.2	1A							
TN3724	TO-237 (91)	50	30	6	1.7 μA	40	30		1A	5	0.25		0.76	10	12	300		50	60	(Note 7)	25
							25		800	2	0.2		0.86	100							
							35		500	1	0.32		1.1	300							
							40		300	1	0.42	0.9	1.2	500							
							60	150	100	1	0.65		1.5	800							
							30		10	1	0.75		1.7	1A							
TN3725	TO-237 (91)	80	50	6	1.7 μA	60	25		1A	5	0.25		0.76	10	10	300		50	60	(Note 7)	25
							20		800	2	0.26		0.86	100							
							35		500	1	0.4		1.1	300							
							40		300	1	0.25	0.9	1.2	500							
							60	150	100	1	0.8		1.5	800							
							30		10	1	0.9		1.7	1A							

TEST CONDITIONS:

Note 1: V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1.5 mA.

Note 2: V_{CC} = 3V, I_C = 10 mA, I_B^1 = 3 mA, I_B^2 = 1 mA.

Note 3: V_{CC} = 10V, I_C = 300 mA, $I_B^1 = I_B^2$ = 30 mA.

Note 4: V_{CC} = 2V, I_C = 30 mA, $I_B^1 = I_B^2$ = 3 mA.

Note 5: V_{CC} = 25V, I_C = 300 mA, $I_B^1 = I_B^2$ = 30 mA.

Note 6: V_{CC} = 25V, I_C = 500 mA, $I_B^1 = I_B^2$ = 50 mA.

Note 7: V_{CC} = 30V, I_C = 500 mA, $I_B^1 = I_B^2$ = 50 mA.

Note 8: V_{CC} = 30V, I_C = 1A, $I_B^1 = I_B^2$ = 100 mA.

Note 9: V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 1 mA.

Note 10: V_{CC} = 10.7V, I_C = 1A, $I_B^1 = I_B^2$ = 100 mA.

Note 11: V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 3 mA.

Note 12: V_{CC} = 3V, I_C = 10 mA, $I_B^1 = I_B^2$ = 3.3 mA.

National Semiconductor

Low Level Amplifiers

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
2N929	TO-18	45	45	5	10	45		350	10	5	1.0	0.6	1.0	10	8	30		0.5	4	(Note 1)	07
							60		500 μA	5											
							40	120	10 μA	5											
2N929A	TO-18	60	45	6	2	45		350	10	5	0.5	0.7	0.9	10	6	45		0.5	4		07
							60		500 μA	5											
							40	120	10 μA	5											
							25		1 μA	5											
2N930	TO-18	45	45	5	10	45		600	10	5	1.0	0.6	1.0	10	8	30		0.5	3	(Note 1)	07
Avail. JAN/TX/V							150		500 μA	5											
Versions							100	300	10 μA	5											
2N2484	TO-18	60	60	6	10	45	250		1	5	0.35			1	10	15		0.05	3	(Note 1)	07
							200		500 μA	5											
							175		100 μA	5											
							100	500	10 μA	5											
							30		1 μA	5											
2N3117	TO-18	60	60	6	10	45	400		1	5	0.35			1	4.5	60		0.5	1.5	(Note 2)	07
							300		100 μA	5											
							250		10 μA	5											
							100		1 μA	5											
2N3246	TO-18	60	40	10	1	40		800	10	5	0.5	0.7	0.9	5	5	60	180	1	2	(Note 1)	07
							400		1	5											
							350		500 μA	5											
							300		100 μA	5											
							200		10 μA	5											
							150		1 μA	5											
2N3565	Same as PN3565																				11
2N3707	TO-92 (94)	30	30	6	100	20	100	400	100 μA	5	1.0			10					5	(Note 1)	11
2N3708	TO-92 (94)	30	30	6	100	20	45	660	1	5	1.0			10							11

Low Level Amplifiers (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
2N3709	TO-92 (94)	30	30		100	20	45	165	1	5	1.0			10							11
2N3710	TO-92 (94)	30	30	6	100	20	90	330	1	5	1.0			10							11
2N3711	TO-92 (94)	30	30	6	100	20	180	660	1	5	1.0			10							11
2N3858A	TO-92 (94)	60	60	6	500	18	60 45	120	10 1	1 1					4	90	250	2			11
2N3859A	TO-92 (94)	60	60	6	500	18	100 75	200	10 1	1 1					4	90	250	2			11
2N3877	TO-92 (94)	70	70	4	500	70	20	250	2	4.5		0.5	0.9	10							11
2N3877A	TO-92 (94)	85	85	4	500	70	20	250	2	4.5		0.5	0.9	10							11
2N3900A	TO-92 (94)	18	18	5	100	18	250	500	2	4.5					12				5	(Note 4)	11
2N3901	TO-92 (94)	18	18	5	100	15	350	700	2	4.5									5	(Note 4)	11
2N4286	TO-92 (94)	30	25	6	50	25	150 100	600	1 100 μA	5 5	0.35		0.8	1	6	40		1			11
2N4287	TO-92 (94)	45	45	7	10	30	150 100	600	1 100 μA	5 5	0.35		0.8	1	6	40		1	5	(Note 1)	11
2N4409	TO-92 (92)	80	50	5	10	60	60 60	400	10 1	1 1	0.2		0.8	1	12	60	300	10			11
2N4410	TO-92 (92)	120	80	5	10	100	60 60	400	10 1	1 1	0.2		0.8	1	12	60	300	10			11
2N4966	TO-92 (92)	50	40	6	25	25	40 50	200	0.01 10	5 5	0.4			10	6	40		1			11
2N4967	TO-92 (92)	50	40	6	25	25	100 120	600	0.01 10	5 5	0.4			10	6	40		1			11
2N4968	TO-92 (92)	30	25	6	50	25	40 50	200	0.01 10	5 5	0.4			10	6						11

Low Level Amplifiers (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
2N5088	TO-92 (92)	35	30		50	20	300		10	5	0.5			10	4				3	(Note 3)	11
							350		1	5											
							300	900	100 μA	5											
2N5089	TO-92 (92)	30	25		50	15	400		10	5	0.5			10	4				2	(Note 3)	11
							450		1	5											
							400	1200	100 μA	5											
2N5133		Same as PN5133																			11
2N5209	TO-92 (92)	50	50		50	35	150		10	5	0.7			10	4	30		0.5	4	(Note 5)	11
							150		1	5											
							100	300	100 μA	5											
2N5210	TO-92 (92)	50	50		50	35	250		10	5	0.7			10	4	30		0.5	3	(Note 4)	11
							250		1	5											
							200	600	100 μA	5											
2N5232	TO-92 (94)		50		30	50	250	500	2	5	0.125			10	4						11
2N5961	TO-92 (92)	60	60	8	2	45	100		0.01	5	0.2			10	4	100		10	6	(Notes 7 & 11)	11
							120		0.1	5											
							135		1	5											
																			3	(Note 10)	
							150	700	10	5									3	(Note 12)	
2N5962	TO-92 (92)	45	45	8	2	30	450		0.01	5	0.2			10	4	100		10	6	(Note 7)	11
							500		0.1	5									4	(Note 8)	
							550		1	5									8	(Note 9)	
																			3	(Note 10)	
							600	1400	10	5									3	(Note 12)	
2N5232A	TO-92 (94)		50		30	50	250	500	2	5	0.125			10	4				5	(Note 2)	11
MPS3707	TO-92 (92)		30		100	20	100	400	100 μA	5	1.0			10					5	(Note 4)	11
MPS3708	TO-92 (92)		30		100	20	45	660	1	5	1.0			10							11
MPS3709	TO-92 (92)		30		100	20	45	165	1	5	1.0			10							11
MPS3710	TO-92 (92)		30		100	20	90	330	1	5	1.0			10							11

Low Level Amplifiers (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
MPS3711	TO-92 (92)	30	30		100	20	180	660	1	5	1.0			10							11
MPS6571	TO-92 (92)	25	20	3	50	20	250	1000	100 μA	5	0.5			10	4.5	50		0.5			11
MPSA09	TO-92 (92)	50	50		100	25	100	600	100 μA	5	0.9			10	5	600		0.5			11
MPSA18	TO-92 (92)	45	45	6.5	50	30	400		0.01	5	0.3			50	3	100		1	1.5	(Note 4)	11
							500		0.1	5											
							500		1	5											
							500	1500	10	5											
PE4020	TO-92 (92)	60	60	8	2	45	150	950	10	5	0.3			50	4	100	800	10	6	(Note 9)	11
							135		1	5									3	(Note 7)	
							120		0.1	5											
							100		0.01	5									3	(Note 10)	
PN930	TO-92 (92)	45	45	5	10	45		600	10	5	1.0	0.6	1.0	10	8	30		0.5	3	(Note 1)	11
							150		500 μA	5											
							100	300	10 μA	5											
PN2484	TO-92 (92)	60	60	6	10	45		600	10	5	0.35			10	6				3	1	11
							250		1	5											
							200		500 μA	5											
							175		100 μA	5											
							100	500	10 μA	5											
							30		1 μA	5											
PN3565	TO-92 (92)	30	25	6	50	25	150	600	1	10	0.35			1	4	40	240	1			11
PN5133	TO-92 (92)	20	18	3	50	15	60	1000	1	5	0.4			1	5	40	240	1			11

TEST CONDITIONS:

Note 1: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 10 Hz − 15.7 kHz.

Note 2: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 1 kHz.

Note 3: $I_C = 5\ \mu A$, $V_{CE} = 5V$, f = 1 kHz.

Note 4: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 10 Hz − 15.7 kHz.

Note 5: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 10 kHz.

Note 6: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 5 kHz.

Note 7: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz, $R_S = 1\ k\Omega$.

Note 8: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz, $R_S = 10\ k\Omega$.

Note 9: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz, $R_S = 100\ k\Omega$.

Note 10: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 1 kHz, $R_S = 10\ k\Omega$.

Note 11: $I_C/I_B = 20$.

Note 12: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 10 Hz − 10 kHz, $R_S = 10\ k\Omega$.

National Semiconductor

RF Amplifiers and Oscillators

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{ro} (pF) Min	C_{ob}/C_{ro} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
2N2857	TO-72	30	15	2.5	10	15	30	150	3	1						1	1000	1900	5	4.5	450	40
2N3478	TO-72	30	15	2	20	1	25	150	2	8						1	750	1600	5	4.5	200	40
2N3600	TO-72	30	15	3	10	15	20	150	3	1						1	850	1500	5	4.5	200	40
2N3932	TO-72	30	20	2.5	10	15	40	150	2	8						0.55	750	1600	2	4.5	200	40
2N3933	TO-72	40	30	2.5	10	15	60	200	2	8						0.55	750	1600	2	4	200	40
2N4259	TO-72	40	30	2.5	10	15	60	250	2	8						0.55	750	1600	2	5	450	40
2N5179	TO-72	20	12	2.5	20	15	25	250	3	1	0.4		1.0	10		1	900	2000	5	4.5	200	40
2N5180	TO-72	30	15	2	500	8	20	200	2	8						1	650	1700	2			40
MRF501	TO-72	25	15	3.5	50	1	30	250	1	6							600		5			40
MRF502	TO-72	35	15	3.5	20	1	40	170	1	6							800		5			40
PN5179	TO-92 (92)	20	15	2.5	2	15	25	250	3	1	0.4		1.0	10		1.0	900	2000	5	4.5	200	40
MPS6539	TO-92 (91)	20	20	3	50	15	20		4	10						0.7	500		4	4.5	100	42
MPS6548	TO-92 (91)	30	25	3	100	25	25		4	10	0.5		0.95	4		0.7	650		4			42
MPSH10	TO-92 (91)	30	25	3	100	25	60		4	10	0.5			4	0.35	0.65	650		4			42
2N917	TO-72	30	15	3	1	15	20		3	1	0.5		0.87	3		3	500		4	6	60	43
2N918	TO-72	30	15	3	10	15	20		3	1	0.4		1.0	10		3	600		4	6	60	43
2N3563		Same as PN3563																				43
2N3564		Same as PN3564																				43
2N3662	TO-92 (94)	18	12	3	500	15	20		8	10					0.8	1.7	700	2100	5	6.5	60	43

RF Amplifiers and Oscillators (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{ro} (pF) Min	C_{ob}/C_{ro} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
2N3663	TO-92 (94)	30	12	3	500	15	20		8	10					0.8	1.7	700	2100	5	6.5	60	43
2N3825	TO-92 (94)	30	15	4	100	15	20		2	10	0.25			2		3.5	200	800	2	5.5	1	43
2N4292	TO-92 (94)	30	15	3	500	15	20		3	1	0.6			10		3.5	600		4	6	60	43
2N4293	TO-92 (94)	30	15	3	500	15	20		3	1	0.6			10		3.5	600		4	6	60	43
2N5130		Same as PN5130																				43
2N5770	TO-92 (92)	30	15	4.5	10	15	50 20	200	8 3	10 1	0.4		1.0	10	0.7	1.1	900	1800	8	6	60	43
MPS918	TO-92 (92)	30	12	3	10	15	20		3	1	0.4		1.0	10	3		600		4	6	60	43
MPS3563		Same as PN3563																				43
MPS6507	TO-92 (92)	30*	20		5	15	25		2	10						2.5	700		10			43
MPS6511	TO-92 (92)	30*	20		50	15	25		10	10						2.5						43
MPS6541	TO-92 (92)	30*	20	4	50	15	25		4	10						1.7	600	1500	4			43
MPS5770	TO-92 (92)	30	15	4.5	10	15	50 80	200	8 3	1 1	0.4		1.0	10			800	1800	8			43
PN918	TO-92 (92)	30	15	3	10	15	20		3	1	0.4		1.0	10		1.7	600		4	6	60	43
PN3563	TO-92 (92)	30	15	2	50	15	20	200	8	10						1.7	600	1500	8			43
PN3564	TO-92 (92)	30	15	4	50	15	20	500	15	10	0.3		0.97	20		3.5	400	1200	15			43

RF Amplifiers and Oscillators (Continued)

Type No.	Case Style	V_{CES}^* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{ro} (pF) Min	C_{ob}/C_{ro} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
PN5130	TO-92 (92)	30	12	1	50	10	15	250	8	10	0.6		1.0	10		1.7	450		8			43
2N4134	TO-72	30	30	3	50	10	25	200	4	5						0.5	350	800	4	2.5	60	44
2N4135	TO-72	30	30	3	50	10	25	200	4	5						0.5	425	800	4	5	450	44
MPS6568A	TO-92	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.65	375	800	4	3.3	200	44
MPS6569	TO-92	20	20	3	50	10	20	200	4	5	3		0.96	10	0.25	0.5	300	800	4	6	45	44
MPS6570	TO-92	20	20	3	50	10	20	200	4	5	3		0.96	10	0.25	0.5	300	800	4	6	45	44
MPSH30	TO-92	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.65	300	800	4	6	45	44
MPSH31	TO-92	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.65	300	800	4	6	45	44
SE5020	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	375	800	4	3.3	200	44
SE5021	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	375	800	4	4	200	44
SE5022	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300	800	4			44
SE5023	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300	800	4	6	45	44
SE5024	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300	800	4	6	45	44
SE5050	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300		4	4	100	44
SE5051	TO-72	20	20	3	50	10	20	200	4	5	3.0		0.96	10	0.25	0.5	300		4			44
SE5052	TO-72	20	20	3	50	10					3.0			10			375		4	4	200	44
MPS6542	TO-92 (96)	30*	20		50	15	25		2	10						1.5	700		10			47
MPS6543	TO-92 (96)	35	20	3	100	25	25		4	10	0.35		0.05	10		1	750		4			47
MPS6546	TO-92 (96)	35	25	3	100	25	20		2	10	0.35			10		0.45	600		2			47
MPS6547	TO-92 (96)	35	25	3	100	25	20		2	5	0.35			10		0.35	600		2			47
MPSH11	TO-92 (96)	30	25	3	100	25	60		4	10	0.5			4	0.6	0.9	650	4				47

RF Amplifiers and Oscillators (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob}/C_{ro} (pF) Min	C_{ob}/C_{ro} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	@ Freq (MHz)	Process No.
MPSH19	TO-92 (96)	30	25	3	100	15	45		4	10						0.65	300		4			47
MPSH24	TO-92 (96)	40	30	4	50	15	30		8	10						0.36	400		8			47
MPSH34	TO-92 (96)	45	45	4	50	30	15 40		20 7	2 15	0.5			20		0.32	500		15			47
TIS86	TO-92 (96)	30	30		100	15	40	200	4	10	0.5			15		0.45	500		4	5	200	47
TIS87	TO-92 (96)	45	45		100	15	30	150	12	12	0.5			15		0.45	500		12			47
MPS6540	TO-92 (96)	30	30	4	100	25	25		2	10	0.5			10		0.65	350		2			49
MPS6544	TO-92 (96)	60	45	4	500	35	20		30	10	0.5			30		0.65						49
MPS6567	TO-92 (96)		40	5	500	35	25		10	5	0.5			10		0.7						49
MPSH20	TO-92 (96)	40	30	4	50	15	25		4	10			0.95	10		0.65	400		4			49
MPSH37	TO-92 (96)		40	5	500	35	25		5	10	0.5			10		0.7	300		5			49

National Semiconductor

General Purpose Amplifiers and Switches

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE}		@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V)		@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz)		@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max				Min	Max			Min	Max					
2N2712	TO-92 (94)	18	18	5	500	18	75	225	2	4.5					12	90	300	2				10
2N2714	TO-92 (94)	18	18	5	500	18	75	225	2	4.5	0.3	0.6	1.2	50								10
2N2923	TO-92 (94)	25	25	5	100	25	90	180 (1 kHz)	2	10					10							10
2N2924	TO-92 (94)	25	25	5	100	25	150	300 (1 kHz)	2	10					10							10
2N2925	TO-92 (94)	25	25	5	100	25	235	470 (1 kHz)	2	10					10							10
2N2926	TO-92 (94)	18	18	5	500	18	35	470 (1 kHz)	2	10					10							10
2N3390	TO-92 (94)	25	25	5	100	18	400	800	2	4.5					10							10
2N3391	TO-92 (94)	25	25	5	100	18	250	500	2	4.5					10					5	(Note 5)	10
2N3392	TO-92 (94)	25	25	5	100	18	150	300	2	4.5					10							10
2N3393	TO-92 (94)	25	25	5	100	18	90	180	2	4.5					10							10
2N3394	TO-92 (94)	25	25	5	100	18	55	110	2	4.5					10							10
2N3395	TO-92 (94)	25	25	5	100	18	150	500	2	4.5					10							10

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V)	V_{CEO} (V)	V_{EBO} (V)	I_{CBO} (nA) @	V_{CB} (V)	h_{FE}	@	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) &	$V_{BE(SAT)}$ (V) @		I_C (mA)	C_{ob} (pF)	f_T (MHz) @		I_C (mA)	t_{off} (ns)	NF (dB)	Test Conditions	Process No.
		Min	Min	Min	Min		Min	Max			Max	Min	Max		Max	Min	Max		Max	Max		
2N3396	TO-92 (94)	25	25	5	100	18	90	500	2	4.5					10							10
2N3397	TO-92 (94)	25	25	5	100	18	55	500	2	4.5					10							10
2N3398	TO-92 (94)	25	25	5	100	18	55	800	2	4.5					10							10
2N3414	TO-92 (94)	25	25	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								10
2N3415	TO-92 (94)	25	25	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								10
2N3416	TO-92 (94)	50	50	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								10
2N3417	TO-92 (94)	50	50	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								10
2N3641	Same as PN3641																					10
2N3642	Same as PN3642																					10
2N3643	Same as PN3643																					10
2N3693	Same as PN3693																					10
2N3694	Same as PN3694																					10
2N3721	TO-92 (94)	18	18	5	500	18	60	660 (1 kHz)	2	10					12							10
2N3859	TO-92 (94)	30	30	4	500	18	100	200	2	4.5					4	90	250	2				10
2N3860	TO-92 (94)	30	30	4	500	18	150	300	2	4.5					4	90	250	2				10
2N4140	Same as PN4140																					10
2N4141	Same as PN4141																					10
2N4424	TO-92 (94)	40	40	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								10
2N4969	Same as PN2221																					10

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4970	TO-92 (92)	50	30	5			100	350	150	10	0.4	0.6	1.2	150	8	200		20				10
							70		10	10												
							50		150	1												
2N5127	Same as PN5127																					10
2N5128	Same as PN5128																					10
2N5129	Same as PN5129																					10
2N5131	Same as PN5131																					10
2N5132	Same as PN5132																					10
2N5135	Same as PN5135																					10
2N5136	Same as PN5136																					10
2N5137	Same as PN5137																					10
2N5172	TO-92 (94)	25	25	5	100	25	100	500	10	10	0.25			10	10							10
2N5219	TO-92 (94)	20	15	3	100	10	35	500	2	10	0.4		1.0	10	4	150		10				10
2N5223	TO-92 (92)	25	20	3	100	10	50	500	2	10	0.7		1.2	10	4	150		10				10
MPQ100	TO-116 (39)	75	45	6	50	60	80		0.1	1	0.2		0.85	10	4.5	250		20		4	(Note 12)	10
							100	450	10	1												
							100		100	1	0.4		1.0	200								
							100	350	150	1												
MPQ2222	TO-116 (39)	60	40	5	50	50	75		10	10	0.4		1.3	150	8	200		20				10
							100		150	10												
							30		300	10	1.6		2.6	300								
MPS2923	TO-92 (92)	25	25	5	500	25	90	180	2	10					12							10
MPS2924	TO-92 (92)	25	25	5	500	25	150	300	2	10					12							10
MPS2925	TO-92 (92)	25	25	5	500	25	235	470	2	10					12							10

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE}		@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V)		@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz)		@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max				Min	Max			Min	Max					
MPS2926	TO-92 (92)	25	25	5	500	18	35	470	2	10					12							10
							(1 kHz) (5 Groups)															
MPS3392	TO-92 (92)	25	25	5	100	18	150	300	2	4.5					10							10
MPS3393	TO-92 (92)		25		100	18	90	180	2	4.5					10							10
MPS3394	TO-92 (92)		25		100	18	55	110	2	4.5					10							10
MPS3395	TO-92 (92)		25		100	18	150	500	2	4.5					10							10
MPS3396	TO-92 (92)		25		100	18	90	500	2	4.5					10							10
MPS3397	TO-92 (92)		25		100	18	55	500	2	4.5					10							10
MPS3398	TO-92 (92)		25		100	18	55	800	2	4.5					10							10
MPS3693	TO-92 (92)	45	45	4	50	35	40	160	10	10					10	200		10		4	(Note 9)	10
MPS3694	TO-92 (92)	45	45	4	50	35	100	400	10	10					10	200		10		4	(Note 9)	10
MPS3903	TO-92 (92)	60	40	6			20		0.1	1	0.2	0.65	0.85	10	4	200		10		5	(Note 8)	10
							35		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.3		1.0	50								
MPS3904	TO-92 (92)	60	40	6			40		0.1	1	0.2	0.65	0.85	10	4	200		10		5	(Note 8)	10
							70		1	1												
							100	300	10	1												
							60		50	1												
							10		100	1	0.3		1.0	50								
MPS5172	TO-92 (92)	25	25	5	100	25	100	500	10	10	0.25			10	10							10

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS6520	TO-92		25	4	50	30	200	400	2	10	0.5			50	4					3	(Note 10)	10
	(92)						100		100 µA	10												
MPS6521	TO-92		25	4	50	30	200	600	2	10	0.5			50	4					3	(Note 10)	10
	(92)						150		100 µA	10												
MPS6566	TO-92	60	45	4	100	30	100	400	2	10	0.4			10	4	200		10				10
	(92)																					
MPS6573	TO-92		35		100	35	100		100 µA	5	0.5			10	12	100	300	10				10
	(92)						200	500	10	5												
MPS6574	TO-92		35		100	35	100	300	1	5	0.5			10	12	100	300	10				10
	(92)						(4 Groups)															
MPS6575	TO-92		45		100	45	100		100 µA	5	0.5			10	12	100	300	10				10
	(92)						200	500	10	5												
MPS6576	TO-92		45		100	45	100	300	1	5	0.5			10	12	100	300	10				10
	(92)						(4 Groups)															
MPS8098	TO-92	60	60	6	100	60	100	300	1	5	0.3			100	6	150		10				10
	(92)						100		10	5												
							75		100	5												
MPS8099	TO-92	80	80	6	100	60	100	300	1	5	0.3			100	6	150		10				10
	(92)						100		10	5												
							75		100	5												
MPSA10	TO-92		40	4	100	30	40	400	5	10					4	50		5				10
	(92)																					
MPSA20	TO-92		40	4	100	30	40	400	5	10					4	125		5				10
	(92)																					
PN100	TO-92	75	45	6	50	60	80		0.1	1	0.2		0.85	10	4.5	250		20		4	(Note 12)	10
	(92)						100	450	10	1												
							100		100	1	0.4		1.0	200								
							100	350	150	5												
PN100A	TO-92	75	45	6	50	60	300	600	10	1	0.2		0.85		4.5	250		20		4	(Note 12)	10
	(92)						100		100	1												
							220		0.1	5	0.4		1.0									

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN101	TO-92		65	6	50										4	150		20				10
	(92)																					
PN2221	TO-92	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20	285		(Note 2)	10
	(92)						20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
PN2221A	TO-92	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		(Note 2)	10
	(92)						20		150	1												
							40	120	150	10	1.0		2.0	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
PN2222	TO-92	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				10
	(92)						50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	1												
							50		1	1												
							35		100 μA	1												
PN3641	TO-92	60	30	5	50*	50	15		500	10	0.22			150	8	250		50				10
	(92)						40	120	150	10												
PN3642	TO-92	60	45	5	50*	50	15		500	10	0.22			150	8	250		50				10
	(92)						40	120	150	10												
PN3643	TO-92	60	30	5	50*	50	20		500	10	0.22			150	8	250		50				10
	(92)						100	300	150	10												
PN3694	TO-92	45	45	4	50	30	100	400	10	1					6	200		10				10
	(92)																					
PN4140	TO-92	60	30	5			20		500	10	0.4		1.3	150	8	250		20	310		(Note 2)	10
	(92)						20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												

General Purpose Amps and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN4141	TO-92	60	30	5			30		500	10	0.4		1.3	150	8	250		20	310		(Note 2)	10
	(92)						50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		100 µA	10												
PN5127	TO-92	20	12	3	50	10	15	300	2	10	0.3		1.0	10	4	150		2				10
	(92)																					
PN5128	TO-92	15	12	3	50	10	35	350	50	10	0.25		1.1	150	10	200	800	50				10
	(92)						20		10	10												
PN5129	TO-92	15	12	3	50	10	35	350	50	10	0.25		1.1	150	10	200	800	50				10
	(92)						20		10	10												
PN5131	TO-92	20	15	3	50	10	35	500	10	1	1.0			10	6	100		10				10
	(92)																					
PN5132	TO-92	20	20	3	50	10	30	400	10	10	2.0		0.9	10	4	200		10				10
	(92)																					
PN5135	TO-92	30	25	4	300	15	50	60*	10	10	1.0		1.0	100	25	40	500	30				10
	(92)						15		2	10												
PN5136	TO-92	30	20	3	100	20	20	400	150	1	0.25		1.1	150	35	40	400	50				10
	(92)						20		30	1												
PN5137	TO-92	30	20	3	100	20	20	400	150	1	0.25		1.1	150	35	40	400	50				10
	(92)						20		30	1												
TIS90	TO-92	40	40	5	100	20	100	300	50	2	0.25	0.6	1	50								10
	(94)																					
TIS92	TO-92	40	40	5	100	20	100	300	50	2	0.25	0.6	1	50								10
	(97)																					
TIS97	TO-92		40		10	40	250	700	0.1	5										3	(Note 7)	10
	(97)																					
TIS98	TO-92	60			10	40	100	300	1	5	0.5			100		2		10				10
	(97)																					
TIS99	TO-92		65		10	40	55	300	100	5	0.5			100		2		10				10
	(97)																					

General Purpose Amplifers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN2218A	TO-237	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		(Note 2)	10
	(91)						20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		100 μA	10												
TN2219	TO-237	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				10
	(91)						50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		0.1	10												
TN2219A	TO-237	75	40	6	10	60	40		500	10	0.3	0.6	1.2	150	8	250		20		4	(Note 3)	10
	(91)						50		150	1												
							100	300	150	10	1.0		2.0	500								
							75		10	10												
							50		1	10												
							35		0.1	10												
2N3704	TO-92	50	30	5	100	20	100	300	50	2	0.6			100	12	100		50				13
	(94)																					
2N3705	TO-92	50	30	5	100	20	50	150	50	2	0.8			100	12	100		50				13
	(94)																					
2N3706	TO-92	40	20	5	100	20	30	600	50	2	1.0			100	12	100		50				13
	(94)																					
2N3794	TO-92	40	20	5	500	15	100		100	10	0.4			10	10	100	600	10				13
	(94)						100	600	10	10												
							35		1	10												
2N4400	TO-92	60	40	6			20		500	2	0.4	0.75	0.95	150	6.5	200		20	255		(Note 2)	13
	(92)						50	150	150	1												
							40		10	1	0.75		1.2	500								
							20		1	1												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4401	TO-92	60	40	6			40		500	2	0.4	0.75	0.95	150	6.5	250		20	255		(Note 2)	13
	(92)						100	300	150	1												
							80		10	1	0.75		1.2	500								
							40		1	1												
							20		100 µA	1												
2N4944	TO-92	80	40	5	50	40	40	120	150	1	0.25			150		60	900	50				13
	(92)						40		30													
2N4946	TO-92	80	40	5	50	40	100	300	150	1	0.25			150		60	900	50				13
	(92)						100		30													
2N4951	TO-92	60	30	5	50	40	60	200	150	10	0.3		1.3	150	8	250		20	400		(Note 2)	13
	(94)						40		10	10												
							20		1	10												
2N4952	TO-92	60	30	5	50	40	100	300	150	10	0.3		1.3	150	8	250		20	400		(Note 2)	13
	(94)						75		10	10												
							50		1	10												
2N4953	TO-92	60	30	5	50	40	200	600	150	10	0.3		1.3	150	8	250		20	400		(Note 2)	13
	(94)						150		10	10												
							75		1	10												
2N4954	TO-92	40	30	5	50	30	60	600	150	10	0.3		1.3	150	8	250		20	400		(Note 2)	13
	(94)						40		10	10												
							20		1	10												
2N5220	TO-92	15	15	3	100	10	30	600	50	10	0.5		1.1	150	10	100		20				13
	(92)						25		10	10												
2N5225	TO-92	25	25	4	300	15	30	600	50	10	0.8		1.0	100	20	50		20				13
	(92)						25		50	10												
MPS3704	TO-92	50	30	5	100	20	100	300	50	2	0.6			100	12	100		50				13
	(92)																					
MPS3705	TO-92	50	30	5	100	20	50	150	50	2	0.8			100	12			50				13
	(92)																					
MPS3706	TO-92	40	20	5	100	20	30	600	50	2	1.0			100	12	100		50				13
	(92)																					
MPS6522	TO-92		25	4	50	20	100		0.1	10	0.5			50	4							13
	(92)						200	400	2	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPS6530	TO-92 (92)	60	40	5	50	40	25		500	10	0.5		1.0	100	5							13
							40	120	100	1												
							30		10	1												
MPS6531	TO-92 (92)	60	40	5	50	40	50		500	10	0.3		1.0	100	5							13
							90	270	100	1												
							60		10	1												
MPS6532	TO-92 (92)	50	30	5	100	30	30		100	1	0.5		1.2	100	5							13
PN5449	TO-92 (92)	50	30	5	100	20	100	300	50	2	0.6			100		100		50				13
PN5816	TO-92 (92)	50	40	5	100	25	100	200	2	2	0.75		1.2	500		100		50				13
2N5550	TO-92 (92)	160	140	6	100	100	20		50	5	0.15		1.0	10	6	100	300	10		10	(Note 8)	16
							60	250	10	5												
							60		1	5	0.25		1.2	50								
2N5551	TO-92 (92)	180	160	6	50	120	30		50	5	0.15		1.0	10	6	100	300	10		8	(Note 8)	16
							80	250	10	5												
							80		1	5	0.2		1.0	50								
2N5830	TO-92 (92)	120	100	5	50	100	60		1	5	0.15		0.8	1		100	500	10				16
							80	500	10	5	0.2		1	10								
							80		50	5	0.25		1	50								
2N5831	TO-92 (92)	160	140	5	50	120	60		1	5	0.15		0.8	1	4	100	500	10				16
							80	250	10	5	0.2		1.0	10								
							80		50	5	0.25		1.0	50								
2N5833	TO-92 (92)	200	180	6	10	160	50		1	5	0.15		0.8	1	4	100	500	10				16
							50	250	10	5	0.2		1.0	10								
							50		50	5	0.25		1.0	50								
MPSL01	TO-92 (92)	140	120	6	1 µA	40	50	300	10	5	0.2		1.2	1.0	8	60		10				16
											0.2		1.4	50								
PN5965	TO-92 (92)	200	180	5	50	160	50		1	5	0.15		0.8		4							16
							50	250	10	5	0.2		1.0									
							50		50	5	0.25		1.0									
2N696	TO-5	60		5	1 µA	30	20	60	150	10	1.5		1.3	150	20	40		50				19

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N697	TO-5	60	45	5	1 μA	30	40	120	150	10	1.5		1.3	150	35	50		50				19
2N718	TO-18	60	30	5	1 μA	30	40	120	150	10	1.5		1.3	150	35	50		15				19
2N718A	TO-18	75		7	10	60	20		500	10	1.5		1.3	150	25	60		50		12	(Note 1)	19
							40	120	150	10												
							35		10	10												
							20		100 μA	10												
2N956	TO-18	75	35	7	10	60	40		500	10	1.5		1.3	150	25	70		50		8	(Note 1)	19
							100	300	150	10												
							75		10	10												
							35		100 μA	10												
							20		10 μA	10												
2N1420	TO-5	60	30	5	1 μA	30	100	300	150	10	1.5		1.3	150	35	50		50				19
2N1566	TO-5	80	60	5	1 μA	40	80	200	5	5	1.0			10	10	60		5				19
							(1 kHz)															
2N2218	TO-5	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20			(Note 2)	19
							20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N2218A	TO-5	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		(Note 2)	19
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N2219	TO-5	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				19
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2219A	TO-5	75	40	6	10	60	40		500	10		0.6	1.2	150	8	300		20			(Note 2)	19
also							50		150	1			2	500								
Avail.							100	300	150	10												
JAN/TX/V							75		10	10												
Versions							50		1	10												
							35		100 µA	10												
2N2221	TO-18	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20				19
							20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 µA	10												
2N2221A	TO-18	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		(Note 2)	19
							40	120	150	10												
							35		10	10	1.0		2.0	500								
							25		1	10												
							20		100 µA	10												
2N2222	TO-18	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250		20				19
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		100 µA	10												
2N2222A	TO-18	75	40	6	10	60	40		500	10	0.3	0.6	1.2	150	8	250		20	285	4	(Notes 2 & 3)	19
also							50		150	1												
Avail							100	300	150	10	1		2	500								
JAN/TX/V							75		10	10												
Versions							50		1	10												
							35		100 µA	10												
2N3299	TO-5	60	30	5	10*	50	20		500	10	0.22		1.1	150	8	250		50	150		(Note 4)	19
							20		150	1												
							40	120	150	10												
							35		10	10	0.6		1.5	500								
							25		1	10												
							20		100 µA	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3300	TO-5	60	30	5	10*	50	50		500	10	0.22		1.1	150	8	250		50	150		(Note 4)	19
							50		150	1												
							100	300	150	10												
							75		10	10	0.6		1.5	500								
							50		1	10												
							35		100 μA	10												
2N3301	TO-18	60	30	5	10*	50	20		500	10	0.22		1.1	150	8	250		50	150		(Note 4)	19
							20		150	1												
							40	120	150	10	0.6		1.5	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
2N3302	TO-18	60	30	5	10*	50	50		500	10	0.22		1.1	150	8	250		50	150		(Note 4)	19
							50		150	1												
							100	300	150	10	0.6		1.5	500								
							75		10	10												
							50		1	10												
							35		100 μA	10												
PN2222A	TO-92 (92)	75	40	6	10	60	40		500	10	0.3	0.6	1.2	150	8	300		20	285		(Note 2)	19
							50		150	1												
							100	300	150	10	1.0		2.0	500								
							75		10	1												
							50		1	1												
							35		100 μA	1												
2N915	TO-18	70	50	5	10	60	50	200	10	5	1.0		0.9	10	3.5	250		10				23
2N916	TO-18	45	25	5	10	30	50	200	10	1	0.5		0.9	10	6	300		10				23
2N3691		Same as PN3691																				23
2N3692		Same as PN3692																				23

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3903	TO-92	60	40	6			15		100	1	0.2	0.6	0.85	10	4	250		10	225	6	(Notes 6 & 7)	23
	(92)						30		50	1												
							50	150	10	1	0.3		0.95	50								
							35		1	1												
							20		100 μA	1												
2N3904	TO-92	60	40	6		30	30		100	1	0.2	0.65	0.85	10	4	300		10	250	5	(Notes 6 & 7)	23
	(92)						60		50	1												
							100	300	10	1	0.3		0.95	50								
							70		1	1												
							40		100 μA	1												
2N3946	TO-18	60	40	6			20		50	1	0.2	0.6	0.9	10	4	250		10	375	5	(Notes 6 & 7)	23
							50	150	10	1												
							45		1	1	0.3		1.0	50								
							30		100 μA	1												
2N3947	TO-18	60	40	6			40		50	1	0.2	0.6	0.9	10	4	300		10	450	5	(Notes 6 & 7)	23
							100	300	10	1												
							90		1	1	0.3		1.0	50								
							60		100 μA	1												
2N4123	TO-92	40	30	5	50	20	25		50	1	0.3		0.95	50	4	250		10		6	(Note 7)	23
	(92)						50	150	2	1												
2N4124	TO-92	30	25	5	50	20	60		50	1	0.3		0.95	50	4	300		10		5	(Note 7)	23
	(92)						120	360	2	1												
MPQ3904	TO-116	60	40	6	50	40	30		0.1	1	0.2		0.85	10	4	250		10				23
	(39)						50		1	1												
							75		10	1												
MPQ6700	TO-116	40	40	5	50	30	30		0.1	1	0.25		0.1	10	4.5	200		10				23/66
	(39)						50		1	1												
							70		10	1												
MPS2711	TO-92	18	18	5	500	18	30	90	2	4.5					4							23
	(92)																					
MPS2712	TO-92	18	18	5	500	18	75	225	2	4.5					4							23
	(92)																					

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V)	V_{CEO} (V)	V_{EBO} (V)	I_{CBO} (nA)	@ V_{CB} (V)	h_{FE}		@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V)	& $V_{BE(SAT)}$ (V)		@ I_C (mA)	C_{ob} (pF)	f_T (MHz)		@ I_C (mA)	t_{off} (ns)	NF (dB)	Test Conditions	Process No.
		Min	Min	Min	Min		Min	Max			Max	Min	Max		Max	Min	Max		Max	Max		
MPS2716	TO-92 (92)	18	18	5	500	18	75	225	2	4.5					3.5							23
MPS3721	TO-92 (92)				500	18	60	660 (1 kHz)	2	10					3.5							23
MPS3826	TO-92 (92)	60	45	4	100	30	40	160	10	10					3.5	200	800	10				23
MPS3827	TO-92 (92)	60	45	4	100	30	100	400	10	10					3.5	200	800	10				23
MPS6512	TO-92 (92)	40	30	4	50	30	30		100	10	0.5			50	3.5							23
							50	100	2	10												
MPS6513	TO-92 (92)	40	30	4	50	30	60		100	10	0.5			50	3.5							23
							90	180	2	10												
MPS6514	TO-92 (92)	40	25	4	50	30	90		100	10	0.5			50	3.5							23
							150	300	2	10												
MPS6515	TO-92 (92)	40	25	4	50	30	150		100	10	0.5			50	3.5							23
							250	500	2	10												
MPS6564	TO-92 (92)		45	5	500	40	25		10	5	0.5			10	4							23
MPS6565	TO-92 (92)	60	45	4	100	30	40	160	10	10	0.4			10	3.5							23

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Min @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NS3903	TO-18	60	40	5			15		100	1	0.2	0.65	0.85	10	4	250		10	225		(Note 6)	23
							30		50	1												
							50	150	10	1	0.3		0.95	50								
							35		1	1												
							20		100 μA	1												
NS3904	TO-18	60	40	6			30		100	1	0.2	0.65	0.85	10	4	300		10	250		(Note 6)	23
							60		50	1												
							100	300	10	1	0.3		0.95	50								
							70		1	1												
							40		100 μA	1												
PN3691	TO-92 (92)	35	20	4	50	15	40	160	10	1	0.7		0.9	10	3.5	200	500	10				23
PN3692	TO-92 (92)	35	20	4	50	15	100	400	10	1	0.7		0.9	10	3.5	200	500	10				23
ST3904	TO-92 (92)	60	40	6			40		0.1	1	0.2	0.65	0.85	10	4	300		10	285	8	(Notes 6, 7)	23
							70		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.3		0.95	50								

TEST CONDITIONS:

Note 1: $I_C = 300\ \mu A$, $V_{CE} = 10V$, f = 1 kHz.

Note 2: $I_C = 150$ mA, $V_{CC} = 30V$, $I_B{}^1 = I_B{}^2 = 15$ mA.

Note 3: $I_C = 100\ \mu A$, $V_{CE} = 10V$, f = 1 kHz.

Note 4: $I_C = 300$ mA, $V_{CC} = 25V$, $I_B{}^1 = I_B{}^2 = 30$ mA.

Note 5: $I_C = 100\ \mu A$, $V_{CE} = 4.5V$, f = 15.7 kHz.

Note 6: $I_C = 10$ mA, $V_{CC} = 3V$, $I_B{}^1 = I_B{}^2 = 1$ mA.

Note 7: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 15.7 kHz.

Note 8: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 10 Hz − 15.7 kHz.

Note 9: $I_C = 3$ mA, $V_{CE} = 10V$, f = 1 MHz.

Note 10: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 15.7 kHz.

Note 11: $I_C/I_B = 20$.

Note 12: $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz.

National Semiconductor

Medium Power

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}^* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N699	TO-39	120	60	5	2	60	40	120	150	10	5.0		1.3	150	20	50		50				12
2N1613	TO-5	75	35	7	10	60	20		500	10	1.5		1.3	150	25	60		50		12	(Note 1)	12
also Avail.							40	120	150	10												
JAN/TX/V							35		10	10												
Versions							20		100 μA	10												
2N1711	TO-5	75	35	7	10	60	40		500	10	1.5		1.3	150	25	70		50		8	(Note 1)	12
							100	300	150	10												
							75		10	10												
							35		100 μA	10												
							20		10 μA	10												
2N1890	TO-39	100	60	7	10	75	100	300	150	10	1.2		0.9	50	15	60		50				12
											5.0		1.3	150								
2N1893	TO-39	100	80	7	10	90	40	120	150	10	1.2		0.9	50	15	50		50				12
also Avail.							35		10	10												
JAN/TX/V							20		0.1	10	5.0		1.3	150								
Versions																						
2N2102	TO-39	120	65	7	2	60	10		0.01	10	0.5		1.1	150	15	60		50				12
							20		0.1	10												
							35		10	10												
							40	120	150	10												
							25		500	10												
							10		1A	10												
2N2192	TO-39	60	40	5	10	30	15		0.01	10	0.35		1.3	150	10	50		50				12
							75		0.1	10												
							100	300	10	10												
							70		150	10												
							35		500	10												
							15		1A	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}^* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2192A	TO-39	60	40	5	10	30	15		0.01	10	0.25		1.3	150	20	50		50				12
							75		0.1	10												
							100	300	10	10												
							70		150	10												
							35		500	10												
							15		1A	10												
2N2193	TO-39	80	50	8	10	80	15		0.01	10	0.35		1.3	150	20	50		50				12
							30		0.1	10												
							40	120	10	10												
							30		150	10												
							20		500	10												
							15		1A	10												
2N2193A	TO-39	80	50	8	10	60	15		0.1	10	0.25		1.3	150	20	50		50				12
							30		10	10												
							40	120	150	10												
							30		150	1												
							20		500	10												
							15		1A	10												
2N2243	TO-39	120	80	7	10	60	15		0.1	10	0.35		1.3	150	15	50		50				12
							30		10	10												
							40	120	150	10												
							30		150	1												
							15		500	10												
2N2243A	TO-39	120	80	7	10	60	15		0.1	10	0.25		1.3	150	15	50		50				12
							30		10	10												
							40	120	150	10												
							30		150	1												
							15		500	10												
2N3019	TO-39	140	80	7	10	90	50		0.1	10	0.2		1.1	150	12	100		50				12
also							90		10	10												
Avail.							100	300	150	10												
JAN/TX/V							50		500	10												
Versions							15		1A	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}^* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3020	TO-39	140	80	7	10	90	30	100	0.1	10	0.2		1.1	150	12	80		50				12
							40	120	10	10												
							40	120	150	10	0.5			500								
							30	100	500	10												
							15		1A	10												
2N3053	TO-39	60	40	5	250	30	25		150	2.5	1.4		1.7	150	15	100		50				12
							50	250	150	10												
2N3107	TO-39	100	60	7	10	60	35		0.1	10	0.25		1.1	150	20	70		50	1000	7	(Notes 5 & 6)	12
							100	300	150	10												
							40		500	10	1.0		2.0	1A								
2N3108	TO-39	100	60	7	10	60	20		0.1	10	0.25		1.1	150	20	60		50	600	7	(Notes 5 & 6)	12
							40	120	150	10												
							25		500	10	1.0		2.0	1A								
2N3109	TO-39	80	40	7	10*	60	35		0.1	10	0.25		1.1	150	25	70		50	1000	7	(Notes 5 & 6)	12
							100	300	150	10												
							40		500	10	1.0		2.0	1A								
2N3110	TO-39	80	40	7	10*	60	20		0.1	10	0.25		1.1	150	25	60		50	600	7	(Notes 5 & 6)	12
							40	120	150	10												
							25		500	10	1.0		2.0	1A								
2N3568		Same as PN3568																				12
2N3665	TO-39	120	80	10	50*	60	30		10	10	0.5		1.2	150	12	60		50				12
							40	120	150	10												
							25		500	10	1.2		1.8	500								
2N3666	TO-39	120	80	10	50*	60	70		10	10	0.5		1.2	150	12	60		50				12
							100	300	150	10												
							50		500	10	1.2		1.8	500								
2N3700	TO-18	140	80	7	10	90	50		1	10	0.2		1.1	150	12	100	200	5				12
							90		10	10												
							100	300	150	10	0.5			500								
							50		500	10												
							15		1A	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N3701	TO-18	140	80	7	10	90	40	120	150	10	0.2			150	12	80		50				12
							40	120	10	10												
							30	100	0.1	10	0.5		1.1	500								
							30	100	500	10												
							15		1	10												
2N3945	TO-39	70	50	8	40	60	25		10	10	0.5		1.2	150	12	60		50				12
							40	250	150	10												
							20		500	10	1.8		1.8	500								
2N4945	TO-92	80	80	5	50	40	40	120	150	1	0.25			150		60	900	50				12
	(92)						40		30													
MPSA05	TO-92		60	4	100	60	50		10	1	0.25			100		100		100				12
	(92)						50		100	1												
MPSA06	TO-92		80	4	100	80	50		10	1	0.25			100		100		100				12
	(92)						50		100	1												
PN3568	TO-92	80	60	5	50	40	40		30	1	0.25			150	20	60	600	50				12
	(92)						40	120	150	1												
TN1711	TO-237	75		7	10	60	20		0.01	10	1.5			150	25							12
	(91)						35		0.1	10				150								
							75		10	11	1.3											
							100		150	10												
							40	300	500	10												
TN2102	TO-237	120	65	7	10	60	10		0.01	10	0.5		1.1	150	15	60		50				12
	(91)						20		0.1	10												
							35		10	10												
							40	120	150	10												
							25		500	10												
							10		1A	10												
TN3019	TO-237	140	80	7	10	90	50		1	10	0.2		1.1	150	12	100		50				12
	(91)						90		10	10												
							100	300	150	10	0.5			500								
							50		500	10												
							15		1A	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN3020	TO-237	140	80	7	10	90	30	100	1	10	0.2		1.1	150	12	80		50				12
	(91)						40	120	10	10												
							40	120	150	10	0.5			500								
							30	100	500	10												
							15		1A	10												
TN3053	TO-237	60	40	5	250	30	25		150	2.5	1.4		1.7	150	15	100		50				12
	(91)						50	250	150	10												
PN3566	TO-92	40	30	5	50	20	150	600	10	10	1.0			100	25	4	100	30				13
	(92)						80		2	10												
PN3567	TO-92	80	40	5	50	40	40	120	150	1	0.25			150	20	60	600	50				13
	(92)						40		30	1												
PN3569	TO-92	80	40	5	50	40	100	300	150	1	0.25			150	20	60	600	50				13
	(92)						100		30	1												
2N3566		Same as PN3566																				13
2N3567		Same as PN3567																				13
2N3569		Same as PN3568																				13
2N2657	TO-39	80	50	8	100	60	15		5A	6	0.5		1.5	1A	150	20		200	15		2	34
							40	120	1A	2	3.0		2.5	5A								
2N2658	TO-39	100	80	8	100	60	15		5A	6	0.5		1.5	1A		20		200	15		2	34
							40	120	1A	2	3.0		2.5	5A								
2N2890	TO-39	100	80	5	50 μA	60	25		2A	5	0.5		1.2	1A	70	30		200	15		3	34
							30	90	1A	2												
							20		100	2												
2N2891	TO-39	100	80	5	50 μA	60	50	300	50	10	0.5		1.2	1A	70	30		200	15		3	34
							35		100													
							80	150	1A	2	0.75		1.3	2A								
							40		2A	8												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N5148	TO-39		80		1 µA	60	20		50	5	0.46		1.2	100	70	60		200				34
							30	90	1A	5												
							15		2A	5	0.85		1.5	200								
							5		3A	5												
2N5150	TO-39		80		1 µA	60	60		50	5	0.46		1.2	100	70	60		200				34
							70	200	1A	5												
							30		2A	5	5.0			3A								
							15		3A	5												
2N5336	TO-39		80		10 µA	80	30		600	2	0.7		1.2	2A		30		500	2200		7	34
							30	120	2A	2												
							20		5A	2	1.2		1.8	5A								
2N5338	TO-39		100		10 µA	100	30		600	2	0.7		1.2	2A		30		500	2200		7	34
							30	120	2A	2												
							20		5A	2	1.2		1.8	5A								
2N3439	TO-39	450	350	7	20 µA	360	40	160	20	10	0.5		1.3	50	10	15		10			10	36
2N3440	TO-39		250		20 µA*	300	40	160	20	10												36
2N6591	TO-202	150	150	5	200	100	40	250	10	10	0.8			200								36
	(55)						40	200	100	10												
2N6592	TO-202	200	200	5	200	150	30	250	10	10	0.8			200								36
	(55)						40	200	100	10												
2N6593	TO-202	250	250	5	200	200	30	250	10	10	0.8			200								36
	(55)						30	200	100	10												
2N6720	TO-237	175	150	6	1 µA	150	25		50	10	0.5			100		30	300	50				36
	(91)						30		100	10												
							15		250	10												
							10	50	500	10												
2N6721	TO-237	225	200	6	1 µA	200	25		50	10	0.5			100		30	300	50				36
	(91)						30		100	10												
							15		250	10												
							10	50	500	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N6722	TO-237	275	250	6	1 μA	250	25		50	10	0.5			100		30	300	50				36
	(91)						30		100	10												
							15		250	10												
							10	50	500	10												
2N6723	TO-237	325	300	6	1 μA	300	25		50	10	0.5			100		30	300	50				36
	(91)						30		100	10												
							15		250	10												
							10	50	500	10												
92PU36	TO-237	175	150	6	1 μA	150	25		50	10	0.5			100								36
	(91)						30	300	100	10												
							15		250	10												
							10		500	10												
92PU36A	TO-237	225	200	6	1 μA	200	25		50	10	0.5			100								36
	(91)						30	300	100	10												
							15		250	10												
							10		500	10												
92PU36B	TO-237	275	250	6	1 μA	250	25		50	10	0.5			100								36
	(91)						30	300	100	10												
							15		250	10												
							10		500	10												
92PU36C	TO-237	325	300	6	1 μA	300	25		50	10	0.5			100								36
	(91)						30	300	100	10												
							15		250	10												
							10		500	10												
D40P1	TO-202		120		10 μA	200	20	2		10	1.0			100	15	10		80				36
	(55)						40	80		10												
D40P3	TO-202		180		10 μA	250	20	2		10	1.0		1.5	100	15	10		80				36
	(55)						40	80		10												
D40P5	TO-202		225		10 μA	300	20	2		10	1.0		1.5	100	15	10		80				36
	(55)						40	80		10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSD36	TO-202	175	150	6	1 μA	150	25		50	10	0.5				15	10		50				36
	(55)						30	300	100	10												
							15		250	10												
							10		500	10												
NSD36A	TO-202	225	200	6	1 μA	200	25		50	10	0.5				15	10		50				36
	(55)						30	300	100	10												
							15		250	10												
							10		500	10												
NSD36B	TO-202	275	250	6	1 μA	250	25		50	10	0.5				15	10		50				36
	(55)						30	300	100	10												
							15		250	10												
							10		500	10												
NSD36C	TO-202	325	300	6	1 μA	300	25		50	10	0.5				15	10		50				36
	(55)						30	300	100	10												
							15		250	10												
							10		500	10												
NSD3439	TO-202		350		20 μA	300	30		2	10	0.5		1.3	50	20	15		10				36
	(55)						40	160	20	10												
NSD3440	TO-202		250		500 μA	200	30		2	10	0.5		1.3	50	20	15		10				36
	(55)						40	160	20	10												
TN3440	TO-237		250		20 μA	250	30		2	10	0.5		1.3	50		15		10				36
	(91)						40	160	20	10												
2N6714	TO-237	40	30	5	100	40	55		10	1	0.5			100		50	500	50				37
	(91)						60		100	1												
							50	250	1A	1												
92PU01	TO-237		30	5	100	40	55		10	1	0.5			1A	30	100		50				37
	(91)						60		100	1												
							50		1A	1												
D40D1	TO-202		30		100*	45	50	150	100		0.5		1.5	500								37
	(55)						10		1A													

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
D40D2	TO-202 (55)		30		100*	45	120 20	360	100 1A		0.5		1.5	500								37
D40D3	TO-202 (55)		30		100*	45	290 10		100 1A				1.5	500								37
D40E1	TO-202 (55)		30		100*	40	50 10		100 1A	2 2	1.0		1.3	1A								37
D42C1	TO-202 (56)		30		1 μA	30	25 10		200 1A	1 1	0.5		1.3	1A	30							37
D42C2	TO-202 (56)		30		1 μA	30	40 20	120	200 1A	1 1	0.5		1.3	1A	30							37
D42C3	TO-202 (56)		30		1 μA	30	40 20		200 2A	1 1	0.5		1.3	1A	30							37
NSDU01	TO-202 (55)	40	30	5	100	30	55 60 50		10 100 1A	1 1 1	0.5		1.2	1A	30	50		50				37
92PU01A	TO-237 (91)		40	5	100	50	55 60 50		10 100 1A	1 1 1	0.5			1A	30	100		50				38
92PU05	TO-237 (91)	 60	100 60	 4	100	80	80 50 20	 250	50 250 500	1 1 1	0.35			250	30	50		200				38
D40D4	TO-202 (55)		45		100*	60	50 10	150	100 1A		0.5		1.5	500								38
D40D5	TO-202 (55)		45		100*	60	120 10	360	100 1A		0.5		1.5	500								38
D40D6	TO-202 (55)		45		100*	60	50 10	150	100 1A		1.0		1.5	500								38
D40D7	TO-202 (55)		60		100*	60	50 10	150	100 1A		1.0		1.5	500								38
D40D8	TO-202 (55)		60		100*	75	120 10	360	100 1A	2 2	1.0		1.5	500								38

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
D40E5	TO-202		60		100*	70	50		100	2	1.0		1.3	1A								38
	(55)						10		1A	2												
D42C4	TO-202		45		1 µA	45	25		200	1	0.5		1.3	1A	30							38
	(56)						10		1A	1												
D42C5	TO-202		45		1 µA	45	40	120	200	1	0.5		1.3	1A	30							38
	(56)						20		1A	1												
D42C6	TO-202		45		1 µA	45	40		200	1	0.5		1.3	1A	30							38
	(56)						20		2A	1												
MPS6715	TO-237		40	5	100	50	55		10	1	0.5			1A	30		50					38
	TO-226						60		100	1												
	(99)						50		1A	1												
MPS6717	TO-226	80	80	5	100	60	80		50	1	0.35			250		50	500	200				38
	(99)						50	250	250	1												
							20		500	1												
MPSW01	TO-226		40	5	100	50	55		10	1	0.5			1A	30	100		50				38
	(99)						60		100	1												
							50		1A	1												
NSD102	TO-202	60	45	5	100	60	40		10	5	0.2		0.9	100	30	60		50				38
	(55)						50	150	100	5												
							40		500	5	0.4		1.2	500								
							25		1A	5												
NSD103	TO-202	60	45	5	100	60	50		10	5	0.2		0.9	100	30	60		50				38
	(55)						120	360	100	5												
							50		500	5	0.4		1.2	500								
							30		1A	5												
NSD6179	TO-202		50		500 µA	60	30		500	2	0.5		1.2	500								38
	(55)						40	250	500	2												
							10		1A	2												
NSDU01A	TO-202	50	40	5	100	40	55		10	1	0.5		1.2	1A	30	50		50				38
	(55)						60		100	1												
							50		1A	1												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSDU05	TO-202	60	60	4	100	60	80		50	1	0.35			250	30	50		200				38
	(55)						50		250	1												
							20		500	1												
NSE181	TO-202		60		100	80	50	250	10	1	0.3			500		50		200				38
	(56)						30		500	1												
							12		1A	1.5	0.9		1.5	1.5A								
2N6553	TO-202	100	100	5	100	80	60		10	1	1.0			1A		75	250	100				39
	(55)						80	250	50	1												
							60		250	1												
							25		500	1												
2N6717	TO-237	80	80	5	100	60	80		50	1	0.35			250		50	500	200				39
	(91)						50	250	250	1												
							20		500	1												
2N6718	TO-237	100	100	5	100	80	80		50	1	0.35			350		50	500	200				39
	(91)						50	250	250	1												
							20		500	1												
2N6731	TO-237	100	80	5	100	80	100		10	2	0.35			350		50	500	200				39
	(91)						100	300	350	2												
92PU06	TO-237		100		100	80	20	500	500	1	0.35			250	30	50		200				39
	(91)	80	80	4			50	250	250	1												
							80	50	50	1												
92PU07	TO-237	100	100		100	80	80		50	1	0.35			250	30	50		200				39
	(91)			4			50		250	1												
							20		500	1												
92PU100	TO-237	100	80		100	80	20		10	5	0.35			350	20	50		100				39
	(91)						50	150	100	5												
							10		1A	5												
D40D10	TO-202		75		100*	90	50	150	100	2	1.0		1.5	500								39
	(55)						10		1A	2												
D40D11	TO-202		75		100*	90	120	360	100	2	1.0		1.5	500								39
	(55)						10		1A	2												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
D40D13	TO-202 (55)		75		100*	90	50	150	100	2	1.0		1.5	500								39
D40D14	TO-202 (55)		75		100*	90	120	360	100	2	1.0		1.5	500								39
D40E7	TO-202 (55)		80		100*	90	50		100	2	1.0		1.3	1A								39
							10		1A	2												
MPSW06	TO-226 (99)	80	80	4	100	80	80		50	1	0.35			250	30	50		200				39
							50		250	1												
							20		500	1												
NSD104	TO-202 (55)	100	80	7	100	100	20		10	5	0.2		0.9	100	30	60		50				39
							50	150	100	5												
							10		1A	5	0.5		1.2	500								
NSD105	TO-202 (55)	100	80	7	100	100	10		10	5	0.2		0.9	100	30	60		50				39
							120	360	100	5												
							10		1A	5	0.5		1.2	500								
NSD106	TO-202 (55)	140	100	7	100	140	20		10	5	0.2		0.9	100	30	60		50				39
							50	150	100	5												
							25		500	5	0.5		1.2	500	50							
NSD6178	TO-202 (55)		75		500 μA	80	30		50	2	0.5		1.2	500								39
							40	250	500	2												
							10		1A	2												
NSDU06	TO-202 (55)	80	80	4	100	80	80		50	1	0.35			250	30	50		200				39
							50		250	1												
							20		500	1												
NSDU07	TO-202 (55)	100	100	4	100	100	80		50	1	0.35			250	30	50		200				39
							50		250	1												
							20		500	1												
2N6711	TO-237 (90)	160	160	7	50	100	15		1	10						40	200	10				48
							15		10	10												
							30	200	30	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N6712	TO-237 (90)	250	250	7	50	200	15 15 30	 200	1 10 30	10 10 10						40	200	10				48
2N6713	TO-237 (90)	300	300	7	50	250	15 15 30	 200	1 10 30	10 10 10						40	200	10				48
2N6719	TO-237 (91)	300	300	7	100	200	25 40 40	 200	1 10 30	10 10 10						30	300	15				48
2N6733	TO-237 (91)	200	200	6	100	160	25 40	 200	1 10	10 10	2.0			20		50	200	10				48
2N6734	TO-237 (91)	250	250	6	100	200	25 40	 200	1 10	10 10	2.0					50	200	10				48
2N6735	TO-237 (91)	300	300	6	100	260	25 40	 200	1 10	10 10						50	200	10				48
92PE487	TO-237 (90)	160	160	7	50	100	15 15 30		1 10 30	10 10 10	1.0			30	3							48
92PE488	TO-237 (90)	250	250	7	50	100	15 15 30		10 10 30	10 10 10	1.0			30	3							48
92PE489	TO-237 (90)	300	300	7	50	200	15 15 30		1 10 30	10 10 10	1.0			30	3							48
92PU10	TO-237 (91)		300		100	200	25 40 40		1 10 30	10 10 10	0.75			30	3.5							48
92PU391	TO-237 (91)	200	200	6	100	160	25 40		1 10	10 10	2.0		2.0	20	2.5	50		10				48
92PU392	TO-237 (91)	250	250	6	100	200	25 40		1 10	10 10	2.0		2.0	20	2.5	50		10				48

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
92PU393	TO-237	300	300	6	100	260	25		1	10	2.0		2.0	20	2.5	50		10				48
	(91)						40		10	10												
D40N1	TO-202		250		10 μA	250	20		4	10						50		20				48
	(55)						30	90	20	10												
							20		40	10												
D40N2	TO-202		250		10 μA	250	30		4	10						50		20				48
	(55)						60	180	20	10												
							30		40	10												
D40N3	TO-202		300		10 μA	300	20		4	10						50		20				48
	(55)						30	90	20	10												
							20		40	10												
D40N4	TO-202		300		10 μA	300	30		4	10						50		20				48
	(55)						60	180	20	10												
							30		40	10												
MPS6733	TO-226	200	200	6	100	160	25		1	10	2.0			20		50	200	10				48
	(99)						40	200	10	10												
MPS6734	TO-226	250	250	6	100	200	25		1	10	2.0					50	200	10				48
	(99)						40	200	10	10												
MPS6735	TO-226	300	300	6	100	260	25		1	10						50	200	10				48
	(99)						40	200	10	10												
MPSA42	TO-92	300	300	6	100	200	25		1	10	0.5		0.9	20	3	50		10				48
	(92)						40		10	10												
							40		30	10												
MPSA43	TO-92	200	200	6	100	160	25		1	10	0.4		0.9	20	4	50		10				48
	(92)						40		10	10												
							50	200	30	10												
92PU10	TO-226		300		100	200	25		1	10	0.75			30	3.5							48
MPSW10	(99)						40		10	10												
							40		30	10												
MPSA42	TO-226	300	300	6	100	200	25		1	10	0.5		0.9	20	3	50		10				48
MPSW42	(99)						40		10	10												
							40		30	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}^* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPSA43	TO-226	200	200	6	100	160	25		1	10	0.4		0.9	20	4	50		10				48
MPSW43	(99)						40		10	10												
							5	2000	30	10												
NSD131	TO-202	250	250	7	100	150	15		1	10	1.0		0.85	20	3							48
	(55)						15		10	10												
							30	90	30	10												
NSD132	TO-202	250	250	7	100	150	15		1	10	1.0		0.85	20	3							48
	(55)						30		10	10												
							60	180	30	10												
NSD133	TO-202	300	300	7	100	150	15		1	10	1.0		0.85	20	3							48
	(55)						15		10	10												
							30	90	30	10												
NSD134	TO-202	300	300	7	100	150	15		1	10	1.0		0.85	20	3							48
	(55)						30		10	10												
							60	180	30	10												
NSD135	TO-202	375	375	7	100	150	15		1	10	1.0		0.85	20	3							48
	(55)						30		10	10												
							30		30	10												
NSD457	TO-202	160	160	5	50	100	25		30	10	1.0			30								48
	(55)																					
NSD458	TO-202	250	250	5	50	200	25		30	10	1.0			30								48
	(55)																					
NSD459	TO-202	300	300	5	50	250	25		30	10	1.0			30								48
	(55)																					
NSDU10	TO-202	300	300	8	200	200	25		1	15	1.5		0.8	20	3	60						48
	(55)						40		10	15												
							40		30	10												
NSE457	TO-202	160	160	5	50	100	25		30	10	1.0			30								48
	(55)																					
NSE458	TO-202	250	250	5	50	200	25		30	10	1.0			30								48
	(55)																					

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSE459	TO-202 (55)	300	300	5	50	250	25		30	10	1.0			30								48
TN3742	TO-237 (91)	300	300	7	100	200	10		3	10	0.75		1.0	10	6	30		10				48
							15		10	10												
							20	200	30	10	1.0		1.2	30								
							20		50	20												

TEST CONDITIONS:

Note 1: I_C = 50 mA, V_{CC} = 100V, $I_B{}^1 = I_B{}^2$ = 5 mA.

Note 2: I_C = 500 μA, V_{CE} = 10V, f = 1 kHz.

Note 3: I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA.

Note 4: I_C = 150 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 15 mA.

Note 5: I_C = 100 μA, V_{CC} = 10V, f = 1 kHz.

Note 6: I_C = 500 mA, V_{CC} = 30V, $I_B{}^1 = I_B{}^2$ = 50 mA.

Note 7: I_C = 2A, V_{CC} = 40V, $I_B{}^1 = I_B{}^2$ = 200 mA.

Note 8: I_C = 1 mA, V_{CE} = 6V, f = 60 kHz.

Note 9: I_C/I_B = 8.

Note 10: I_C/I_B = 12.5.

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Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) @	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	Process No.
2N5305	TO-92 (94)				0.1	25	2000	20,000	2	5	1.4			200	10	60		2	05
2N5306	TO-92 (94)				0.1	25	7000	70,000	2	5	1.4			200	10	60		2	05
2N5307	TO-92 (94)				0.1	40	2000	20,000	2	5	1.4			200	10	60		2	05
2N5308	TO-92 (94)				0.1	40	7000	70,000	2	5	1.4			200	10	60		2	05
2N6426	TO-92 (92)	40	40	12	0.05	30	20,000	200,000	10	5	1.2			50	7	150		10	05
							30,000	300,000	100	5									
							20,000	300,000	500	5	1.5		2	500					
2N6427	TO-92 (92)	40	40	12	0.05	30	10,000	100,000	10	5	1.2			50	7	130		10	05
							20,000	200,000	100	5									
							14,000	140,000	500	5	1.5		2	500					
2N6548	TO-202 (55)	50	40	12	0.1	30	25,000	150,000	200	5					7	1		200	05
							15,000		500	5									
							5000		1A	5									
2N6549	TO-202 (55)	50	40	12	0.1	30	15,000	150,000	200	5					7	1		200	05
							10,000		500	5									
							3000		1A	5									
2N6724	TO-237 (91)	50		12			25,000		200	5	1.0			200		100		200	05
							15,000		500	5									
							4000	40,000	1A	5									
2N6725	TO-237 (91)	50		12	0.1	40	25,000		200	5	1.0			200		100		200	05
							15,000		500	5									
							4000	40,000	1A	5									

Darlington (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	@ V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
92PU45	TO-237	50		12	0.1	30	4000		1A	5	1.5		2.0	1A		100		200	05
	(91)						15,000		500	5									
							25,000		200	5	1.0			200					
92PU45A	TO-237	60		12	0.1	40	4000		1A	5	1.5		2.0	1A		100		200	05
	(91)						15,000		500	5									
							25,000		200	5	1.0			200					
D40C1	TO-202		30		0.5*	30	10,000	60,000	200	5	1.5		2.0	500	10				05
	(55)																		
D40C2	TO-202 (55)		30		0.5*	30	40,000		200	5	1.5		2.0	500	10				05
D40C3	TO-202 (55)		30		0.5*	30	90,000		200	5	1.5		2.0	500	10				05
D40C4	TO-202 (55)		40		0.5*	40	10,000	60,000	200	5	1.5		2.0	500	10				05
D40C5	TO-202 (55)		40		0.5*	40	40,000		200	5	1.5		2.0	500	10				05
D40C7	TO-202 (55)		50		0.5*	50	10,000	60,000	200	5	1.5		2.0	500	10				05
D40C8	TO-202 (55)		50		0.5*	50	40,000		200	5	1.5		2.0	500	10				05
D40K1	TO-202		30				10,000		200	5					10				05
	(55)						1000		1.5A	5									
							3000		1A	5									
D40K2	TO-202		50				10,000		200	5									05
	(55)						1000		1.5A	5									
							3000		1A	5									
D40K3	TO-202		30				10,000		200	5									05
	(55)						1000		1.5A	5									
							3000		1A	5									
D40K4	TO-202		50				10,000		200	5									05
	(55)						1000		1.5A	5									
							3000		1A	5									

Darlington (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	@ V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
MPQ6426	TO-116	40	30	12	100	30	5000		10	5	1.5			100	8	125		20	05
							10,000		100	5									
MPQA13	TO-116	30			0.1	30	10,000		100	5	1.5			100		125		10	05
							5000		10	5									
MPS6724	TO-226	50		12			25,000		200	5	1.0			200		100		200	05
	(99)						4000	40,000	1A	5									
MPS6725	TO-226	50		12	0.1	40	25,000		200	5	1.0			200		100		200	05
	(99)						4000	40,000	1A	5									
MPSA12	TO-92	20			0.1	15	20,000		10	5	1.0			10					05
	(92)																		
MPSA13	TO-92	30			0.1	30	10,000		100	5	1.5			100		125		10	05
	(92)						5000		10	5									
MPSA14	TO-92	30			0.1	30	20,000		100	5	1.5			100		125		10	05
	(92)						10,000		10	5									
MPSW13	TO-226	30			0.1	30	10,000		100	5	1.5			100		125		10	05
	(99)						5000		10	5									
MPSW45	TO-226	50		12	0.1	30	4000		1A	5	1.5		2.0	1A		100		200	05
	(99)						15,000		500	5									
							25,000		200	5	1.0			200					
MPSW45A	TO-226	60		12	0.1	40	4000		1A	5	1.5		2.0	1A		100		200	05
	(99)						15,000		500	5									
							25,000		200	5	1.0			200					
NSD151	TO-202		30	12			5000		10	5	1.5			100	8	50		10	05
	(55)						10,000	150,000	100	5									
NSD152	TO-202			12			5000		10	5	1.5			100	8	50		10	05
	(55)						10,000	25,000	100	5									
NSD153	TO-202			12			20,000		10	5	1.5			100	8	50		10	05
	(55)						5000		100	5									
NSD154	TO-202			12			20,000		10	5	1.5			100	8	50		10	05
	(55)						5000		100	5									

Darlington (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) @	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	Process No.
NSDU45	TO-202 (55)	50		12			25,000	150,000	200	5	1.0			200	8	100		200	05
							15,000		500	5									
							4000		1A	5									
NSDU45A	TO-202 (55)	60		12	0.1	10	25,000	150,000	200	5	1.0			200	8	100		200	05
							15,000		500	5									
							4000		1A	5									
2N7051	TO-92 (92)	100	100	12	100	80	20,000		100	5	1.4			200	10	100		100	06
							1000	20,000	1A	5									
2N7052	TO-92	100	100	12	100	80	10,000		100	5	1.5			100	8	100		100	06
							1000	20,000	1A	5									
2N7053		100	100	12	100	80	10,000		100	5	1.5			100	8	100		100	06
							1000	20,000	1A	5									

Section 4

Bipolar PNP Transistors

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National Semiconductor

Saturated Switches

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (nA) Max	NF (dB) Max	Test Conditions	Process No.
2N3304	TO-52	6	6	4	10*	3	20		50	1	0.15	0.7	0.8	1	3.5	500		10	60		(Note 7)	65
							30	120	10	0.3	0.16	0.8	1.0	10								
							15		1	0.5	0.5		1.5	50								
2N3451	TO-52	6	6	4	10*	3	20		50	1	0.16	0.8	1.0	10	5.5	500		10	60		(Note 7)	65
							30	120	10	0.3	0.5		1.5	50								
2N3639		Same as PN3639																				65
2N3640		Same as PN3640																				65
2N4208	TO-52	12	12	4.5	10*	6	30		50	1	0.13		0.8	1	3	700		10	20		(Note 5)	65
							30	120	10	0.3	0.15	0.8	0.95	10								
							15		1	0.5	0.5		1.5	50								
2N4209	TO-52	15	15	4.5	10*	8	40		50	1	0.15		0.8	1	3	850		10	20		(Note 5)	65
							50	120	10	0.3	0.18	0.8	0.95	10								
							35		1	0.5	0.6		1.5	50								
2N4258		Same as PN4258																				65
2N4258A		Same as PN4258A																				65
2N5140		Same as PN5140																				65
2N5228	TO-92 (92)	5	5	3	100*	4	30		10	0.3	0.4	0.65	1.25	10		300		10				65
							15		50	1.0												
2N5771	TO-92 (92)	15	15	4.5	10	8	50	120	10	0.3	0.15		0.8	1	3	700		10	20		(Note 6)	65
							40		50	1.0	0.18	0.8	0.95	10								
							35		1	0.5	0.6		1.5	50								
2N5910		Same as PN5910																				65
MPS3639	TO-92 (92)	Same as PN3639																				65
MPS3640	TO-92 (92)	Same as PN3640																				65

Saturated Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN3639	TO-92	6	6	4	10*	3	20		50	1.0	0.16	0.8	1.0	10	3.5	300		10	60		(Note 7)	65
	(92)						30	120	10	0.3	0.5		1.5	50								
PN3640	TO-92	12	12	4	10*	6	20		50	1.0	0.2	0.8	1.0	10	3.5	300		10	75		(Note 7)	65
	(92)						30	120	10	0.3	0.6		15	50								
PN4258	TO-92	12	12	4.5	10*	6	30		50	1	0.15	0.7	0.95	10	3	700		10	20		(Note 6)	65
	(92)						30	120	10	3												
							15		1	0.8	0.5		1.5	50								
PN4258A	TO-92	12	12	4.5	10*	6	30		50	1	0.15	0.7	0.96	10	3	700		10	18		(Note 6)	65
	(92						30	120	10	3												
							15		1	0.5	0.5		1.5	50								
PN5140	TO-92	5	5	4	50*	3	20	40	10	1	0.2		1.2	10	5	400		10	20		(Note 6)	65
	(92)										0.75			50								
PN5910	TO-92	20	20	4.5	10*	10	30		50	1	0.15	0.75	0.95	10	3	700		10	20		(Note 6)	65
	(92)						30	120	10	0.3												
							15		1	0.5	0.5		1.5	50								
ST5771-1	TO-92	15	15	4.5	10	8	30	150	10	0.3	0.15		0.8	1	3	700		10	30		(Note 6)	65
	(92)						30		1	0.5	0.18	0.8	0.95	10								
							20		50	1	0.6		1.5	50								
ST5771-2	TO-92	15	15	4.5	10	8	40	150	10	0.3	0.15		0.8	1	3	700		10	30		(Note 6)	65
	(92)						35		1	0.5	0.18	0.8	0.95	10								
							30		50	1	0.6		1.5	50								
2N3244	TO-39	40	40	5	50	30	25		750	5	0.3		1.1	150	25	175		50	185		(Note 4)	70
							50	150	500	1												
							60		150	1	0.5	0.75	1.5	500								
2N3245	TO-39	50	50	5	50	50	20		1A	5	0.35		1.1	150	25	150		50	165		(Note 4)	70
							30	90	500	1	0.6	0.75	1.5	500								
							35		150	1	1.2		2	1A								
2N3467	TO-39	40	40	5	100	30	40		1	5	0.3		1.0	150	25	175		50	90		(Note 4)	70
							40	120	500	1												
							40		150	1	0.5	0.8	1.2	500								

Saturated Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (nA) Max	NF (dB) Max	Test Conditions	Process No.
2N3468	TO-39	50	50	5	100	30	20		1	5	0.35		1.0	150	25	150		50	90		(Note 4)	70
							25	75	500	1												
							25		150	1	0.6	0.8	1.2	500								
2N5022	TO-39	50	50	5	100*	30	25		1A	5	0.2		1.0	100	25	170		50	90		(Note 4)	70
							25	100	500	1	0.4	0.8	1.4	500								
							15		100	1	0.8		1.75	1A								
2N5023	TO-39	30	30	5	100*	20	40		1A	5	0.17		1.0	100	25	200		50	90		(Note 4)	70
							40	100	500	1	0.35	0.8	1.4	500								
							30		100	1	0.7		1.75	1A								
MPQ3467	TO-116	40	40	5	100	30	40		1A	5	1.0		1.6	1A	25	175		50			(Note 4)	70
							40	120	500	1	0.5	0.8	1.2	500								
							40		150	1	0.3		1.0	150								
MPQ3468	TO-116	50	50	5	100	30	20		1A	5	1.2		1.6	1A	25	150		50			(Note 4)	70
							25	75	500	1	0.5	0.8	1.2	500								
							25		150	1	0.36		1.0	150								
TN3467	TO-237 (91)	40	40	5	100	30	40		150	1	0.3		1.0	150	25	175		50				70
							40	120	500	1	0.5	0.8	1.2	500								
							40		1A	5	1.0		1.6	1A								

TEST CONDITIONS:

Note 1: I_C = 30 mA, V_{CC} = 3V, I_B^1 = 3 mA, I_B^2 = 1.5 mA.

Note 2: I_C = 30 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1.5 mA.

Note 3: I_C = 30 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 3 mA.

Note 4: I_C = 500 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 50 mA.

Note 5: I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA.

Note 6: I_C = 10 mA, V_{CC} = 1.5V, $I_B^1 = I_B^2$ = 1 mA.

Note 7: I_C = 10 mA, V_{CC} = 1.5V, $I_B^1 = I_B^2$ = 500 μA.

Note 8: I_C = 10 mA, V_{CC} = 2V, $I_B^1 = I_B^2$ = 1 mA.

Note 9: I_C = 50 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 5 mA.

Note 10: I_C = 1A, V_{CC} = 30V, $I_B^1 = I_B^2$ = 100 mA.

National Semiconductor

Low Level Amplifiers

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2605	TO-46	60	45	6	10	45		600	10	5	0.5	0.7	0.9		10	6	30		0.5	3	(Note 2)	62
							150		0.5	5												
							100	300	0.01	5												
2N3550	TO-18	60	45	8	1	45		800	10	5	0.5	0.7	0.9		5	8	60	150	1	4	(Note 1)	62
							300		1	5												
							250		0.1	5												
							200	600	0.01	5												
							125		0.001	5												
2N4058	TO-92 (94)	30	30	6	100	20	100	400	0.1	5	0.7				10					5	(Note 3)	62
2N4059	TO-92 (94)	30	30	6	100	20	45	660	1	5	0.7				10							62
2N4061	TO-92 (94)	30	30	6	100	20	90	330	1	5	0.7				10							62
2N4062	TO-92 (94)	30	30	6	100	20	180	660	1	5	0.7				10							62
2N4248		Same as PN4248																				62
2N4249		Same as PN4249																				62
2N4250		Same as PN4250																				62
2N4250A		Same as PN4250A																				62
2N4288	TO-92 (94)	30	25	6	50	25	75		10	5	0.35		0.8			40		1				62
							150	600	1	5					8							
							100		0.1	5												
2N4289	TO-92 (94)	60	45	7	10	45	75		10	5	0.35		0.8	1	8	40		1		4	(Note 1)	62
							150	600	1	5												
							100		0.1	5												
2N4964		Same as MPSA70																				62
2N4965		Same as 2N5086																				62

Low Level Amplifiers (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N5086	TO-92 (92)	50	50	5	50	35	150		10	5	0.3			10	4	40		0.5		3	(Note 4)	62
							150		1	5												
							150	500	0.1	5												
2N5087	TO-92 (92)	50	50	5	50	35	250		10	5	0.3			10	4	40		0.5		2	(Note 4)	62
							250		1	5												
							250	800	0.1	5												
2N5227	TO-92 (92)	30	30	3	100	10	50	700	2	10	0.4		1.0		10	5	100		10			62
							30		0.1	10												
MPSA70	TO-92 (92)		40	4	100	30	40	400	5	10	0.25				10	4	125		5			62
MPS6523	TO-92 (92)		25	4	50	20	300	600	2	10	0.5				5	4						62
							150		0.1	10												
PN4248	TO-92 (92)	40	40	5	10	40	50		0.1	5	0.25			10	10							62
															6							
PN4249	TO-92 (92)	60	60	5	10	40	100	300	0.1	5	0.25				10	6						62
PN4250	TO-92 (92)	40	40	5	10	40	250	700	0.1	5	0.25				10	6				2	(Note 4)	62
PN4250A	TO-92 (92)	60	60	5	10	50	250	700	0.1	5	0.25				10	6				2	(Note 4)	62

TEST CONDITIONS:

Note 1: $I_C = 10\ \mu A$, $V_{CE} = 5V$, $f = 10$ Hz–15.7 kHz.

Note 2: $I_C = 10\ \mu A$, $V_{CE} = 5V$, $f = 10$ kHz.

Note 3: $I_C = 100\ \mu A$, $V_{CE} = 5V$, $f = 10$ Hz–15.7 kHz.

Note 4: $I_C = 20\ \mu A$, $V_{CE} = 5V$, $f = 10$ Hz–15.7 kHz.

National Semiconductor

General Purpose Amplifiers and Switches

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2904	TO-5	60	40	5	20	50	20		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							40	120	150	10												
							35		10	10	1.6		2.6	500								
							25		1	10												
							20		0.1	10												
2N2904A	TO-5	60	60	5	10	50	40		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							40		150	10												
							40		10	10	1.6		2.6	500								
							40	120	1	10												
							40		0.1	10												
2N2905	TO-5	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
also							100	300	150	10												
Avail.							75		10	10	1.6		2.6	500								
JAN/TX/V							50		1	10												
Versions							35		0.1	10												
2N2905A	TO-5	60	60	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
also							100	300	150	10												
Avail.							100		10	10	1.6		2.6	500								
JAN/TX/V							100		1	10												
Versions							75		0.1	10												
2N2906	TO-18	60	40	5	20	50	20		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							40	120	150	10												
							35		10	10	1.6		2.6	500								
							25		1	10												
							20		0.1	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N2906A	TO-18	60	60	5	10	50	40		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							40	120	150	10												
							40		10	10	1.6		2.6	500								
							40		1	10												
							40		0.1	10												
2N2907	TO-18	60	40	5	20	50	35		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
also							100	300	150	10												
Avail.							75		10	10	1.6		2.6	500								
JAN/TX/V							50		1	10												
Versions							35		0.1	10												
2N2907A	TO-18	60	60	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
also							100	300	150	10												
Avail.							100		10	10	1.6		2.6	500								
JAN/TX/V							100		1	10												
Versions							75		0.1	10												
2N3638		Same as PN3638																				63
2N3638A		Same as PN3638A																				63
2N3644		Same as PN3644																				63
2N3645		Same as PN3645																				63
2N3702	TO-92 (94)	40	25	5	100	20	60	300	50	5	0.25			50	12	100		50				63
2N3703	TO-92 (94)	50	30	5	100	20	30	150	50	5	0.25			50	12	100		50				63
2N4142		Same as PN4142																				63
2N4143		Same as PN4143																				63
2N4290	TO-92 (94)	30	20	5	500	20	50	300	100	10	0.4		1.5	100	10	100		10				63
							40		10	10												
							20		0.1	10												
2N4291	TO-92 (94)	40	30	6	200	30	100	300	100	10	0.4		1.5	100	10	100		10				63
							50		10	10												
							30		0.1	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4402	TO-92	40	40	5			20		500	2	0.4	0.7	0.95	150	10	150		20	255		(Note 4)	63
	(94)						50	150	150	2												
							50		10	1	0.75		1.3	500								
							30		1	1												
2N4403	TO-92	40	40	5			20		500	2					10	200		20	255		(Note 4)	63
	(92)						100	300	150	2	0.4	0.75	0.95	150								
							100		10	1												
							60		1	1	0.75		1.3	500								
							30		0.1	1												
2N4971		Same as PN2906																				63
2N4972		Same as PN2907																				63
2N5142		Same as PN5142																				63
2N5143		Same as PN5143																				63
2N5221	TO-92	15	15	3	100	10	30	600	50	10	0.5		1.1	150	15	100		20				63
	(92)						30		10	10												
2N5226	TO-92	25	25	4	300	15	30	600	50	10	0.8		1.0	100	20	50		20				63
	(92)						25		10	10												
2N5354	TO-92	25	25	4	100	25	40	120	50	1	0.25			50	8							63
	(94)																					
2N5355	TO-92	25	25	4	100	25					0.25			50	8							63
	(94)						100	300	50	1												
2N5365	TO-92	40	40	4	100	40	20		300	5	0.25		1.1	50	8							63
	(94)						40	120	50	1												
							32		2	1	1.0		2.0	200								
2N5366	TO-92	40	40	4	100	40	40		300	5	0.25		1.1	50	8							63
	(94)						100	300	50	1												
							80		2	1	1.0		2.0	200								
2N5447	TO-92	40	25	5			60	300	50	8	0.25			50	12	100		50				63
	(97)																					
2N5817	TO-92	50	40	5	100	25	25		500	2	0.75		1.2	500	15	100		50				63
	(97)						100	200	2	2												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPQ2907	TO-116	60	40	5	50	50	75		10	10	0.4		1.3	150	8	200		20				63
							100		150	10												
							50		300	10	1.6		2.6	300								
MPS3638	TO-92 (92)	Same as PN3638																				63
MPS3638A	TO-92 (92)	Same as PN3638A																				63
MPS3644	TO-92 (92)	Same as PN3644																				63
MPS3645	TO-92 (92)	Same as PN3645																				63
MPS3702	TO-92 (92)	40	25	5	100	20	60	300	50	5	0.25			50	12	100		50				63
MPS3703	TO-92 (92)	50	30	5	100	20	30	150	50	5	0.25			50	12	100		50				63
MPS6533	TO-92 (92)	40	40	4	50	30	25		500	10	0.5		1.0	100	6							63
							40	120	100	1												
							30		10	1												
MPS6534	TO-92 (92)	40	40	4	50	30	50		500	10	0.3		1.0	100	6							63
							90	270	100	1												
							60		10	1												
MPS6535	TO-92 (92)	30	30	4	100	20	30		100	1	0.5		1.2	100	6							63
PN2906	TO-92 (92)	60	40	5	20	50	20		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							40	120	150	10												
							35		10	10	1.6		2.6	500								
							25		1	10												
							20		0.1	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN2906A	TO-92	60	60	5	10	50	40		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
	(92)						40	120	150	10												
							40		10	10	1.6		2.6	500								
							40		1	10												
							40		0.1	10												
PN2907	TO-92	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
	(92)						100	300	150	10												
							75		10	10	1.6		2.6	500								
							60		1	10												
							35		0.1	10												
PN2907A	TO-92	60	60	5	20	50	50		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
	(92)						100	300	150	10												
							100		10	10	1.6		2.6	500								
							100		1	10												
							75		0.1	10												
PN3638	TO-92	25	25	4	35*	15	20		300	2	0.25		1.1	50	20	100		50	170		(Note 1)	63
	(92)						20		50	1												
							30		10	10	1.0	0.8	2.0	300								
PN3836A	TO-92	25	25	4	25*	15	20		300	2	0.25		1.1	50	10	150		50	170		(Note 1)	63
	(92)						100		50	1												
							100		10	10	1/0	0.8	2.0	300								
							80		1	10												
PN3644	TO-92	45	45	5	35*	30	20		300	2	0.25		1.0	50	8	200		20	100		(Note 4)	63
	(92)						100	300	150	10												
							80	240	50	1	0.4		1.3	150								
							100		10	10												
							80		1	10	1.0	0.8	2.0	300								
							40		0.1	10												
PN3645	TO-92	60	60	5	35*	50	20		300	2	0.25		1.0	50	8	200		20	100		(Note 4)	63
	(92)						100	300	150	10												
							80	240	50	1	0.4		1.3	150								
							100		10	10												
							80		1	10	1.0	0.8	2.0	300								
							40		0.1	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN4142	TO-92	60	40	5			20		500	10	0.4		1.3	150	8	200		50	100		(Note 12)	63
	(92)						20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		0.1	10												
PN4143	TO-92	60	40	5			30		500	10	0.4		1.3	150	8	200		50	100		(Note 12)	63
	(92)						50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		0.1	10												
PN5142	TO-92	20	20	4	50*	12	15		300	10	0.5		1.5	50	10	100		50	200		(Note 1)	63
	(92)						30		50	1	0.2	0.8	2.5	300								
PN5143	TO-92	20	20	4	50*	12	15		300	10	0.5		1.5	50	10	100		50	200		(Note 1)	63
	(92)						30		50	1	0.2	0.8	2.5	300								
TIS91	TO-92	40	40	4	100	20	100	300	50	2	0.25	0.6	1.0	50								63
	(94)																					
TIS92	TO-92	40	40	5	100	20	100	300	50	2	0.25	0.6	1.0	50								63
	(97)																					
TIS93	TO-92	40	40	5	100	20	100	300	50	2	0.25			50								63
	(97)																					
TN2904A	TO-237	60	60	5	10	50	40		0.1	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
	(91)						40		1.0	10	1.6		2.6	500								
							40		10	10												
							40	120	150	10												
							40		500	10												
TN2905	TO-237	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
	(91)						100	300	150	10	1.6		2.6	500								
							75		10	10												
							50		1	10												
							35		0.1	10												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN2905A	TO-237	60	60	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
	(91)						100	300	150	10												
							100		10	10	1.6		2.6	500								
							100		1	10												
							75		0.1	10												
2N3905	TO-92	40	40	5			15		100	1	0.25	0.65	0.85	10	4.5	200		10	260	5	(Notes 5, 8)	66
	(92)						30		50	1												
							50	150	10	1	0.4		0.95	50								
							40		1	1												
							30		0.1	1												
2N3906	TO-92	40	40	5			30		100	1	0.25	0.65	0.85	10	4.5	250		10	300	4	(Notes 5, 8)	66
	(92)						80		50	1												
							100	300	10	1	0.4		0.95	50								
							80		1	1												
							60		0.1	1												
2N4121		Same as PN4121																				66
2N4122		Same as PN4122																				66
2N4125	TO-92	30	30	4	50	20	25		50	1	0.4		0.95	50	4.5	200		10		5	(Note 8)	66
	(92)						50	150	2	1												
2N4126	TO-92	25	25	4	50	20	60		50	1	0.4		0.95	50	4.5	250		10		4	(Note 8)	66
	(92)						120	360	2	1												
2N4916		Same as PN4916																				66
2N4917		Same as PN4917																				66
2N5138		Same as PN5138																				66
2N5139		Same as PN5139																				66
MPQ3906	TO-116	60	40	6	50	30	40		0.1	1	0.25		0.85	10	4.5							66
							60		1	1												
							75		10	1												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPQ6700	TO-116	40	40	5	50	30	30		0.1		0.25		0.9	10	4.5	200		10				66 (2) 23 (2)
							50		1													
							70		10													
MPS3905	TO-92 (92)	40	40	5			30		0.1	1	0.25	0.65	0.85	10	4.5	200		10		5	(Note 8)	66
							40		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.4		0.95	50								
MPS3906	TO-92 (92)	40	40	5			60		0.1	1	0.25	0.65	0.85	10	4.5	250		10		4	(Note 8)	66
							80		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.4		0.95	50								
MPS6516	TO-92 (92)	40	40	4	50	30	30		100	10	0.5			50	4							66
							50	100	2	10												
MPS6517	TO-92 (92)	40	40	4	50	30	60		100	10	0.5			50	4							66
							90	180	2	10												
MPS6518	TO-92 (92)		40	4	500	30	90		100	10	0.5			50	4							66
							150	300	2	10												
PN3251	TO-92 (92)	50	40	5			80		0.1	1	0.25	0.6	0.9	10	6	300		10		6	(Note 6)	66
							90		0.001	1												
							100	300	10	1	0.5		1.2	50								
							30		50	1												
PN4121	TO-92 (92)	40	40	5	25*	30	15		50	1	0.13		0.75	1	4.5	400		10	150	4	(Notes 11, 8)	66
							70	200	10	1	0.14	0.7	0.9	10								
							60		1	1	0.3		1.1	50								
							40		0.1	1												
PN4122	TO-92 (92)	40	40	5	25*	30	30		50	1	0.13		0.75	1	4.5	450		10	150	4	(Notes 11, 8)	66
							150	300	10	1												
							150		1	1	0.14	0.7	0.9	10								
							100		0.1	1	0.3		1.1	50								

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN4916	TO-92 (92)	30	30	5	25*	15	15	200	50	1	0.13		0.75	1	4.5	400		10	150	4	(Notes 13, 8)	66
							70		10	1	0.14	0.7	0.9	10								
							60		1	1	0.3	0.75	1.1	50								
							40		0.1	1												
PN4917	TO-92 (92)	30	30	5	25*	15	30		50	1	0.13		0.75	1	4.5	450		10	150	4	(Notes 13, 8)	66
							150	300	10	1	0.14	0.7	0.9	10								
							150		1	1	0.3	0.75	1.1	50								
							100		0.1	1												
PN5138	TO-92 (92)	30	30	5	50	20	50		10	10	0.3		1.0	10	7	30		0.5				66
							50		1	10												
							50	800	0.1	10												
PN5139	TO-92 (92)	20	20	5	50*	15	15		50	10	0.2	0.7	1.0	10	5	300		10	200		(Note 13)	66
							40		10	1												
							40		1	10												
							30		0.1	10	0.5	0.75	1.25	50								
ST3906	TO-92 (92)	40	40	5			60		0.1	1	0.25	0.65	0.85	10	4.5	250		10				66
							80		1	1	0.4		0.95	50								
							100	300	10	1												
							60		50	1												
							30		300	1												
2N6076	TO-92 (94)	25	25	5	100	25	100	300	10	10	0.25		0.8	10								68
MPQ200	TO-116	60	45	6	50	50	80		0.1	1	0.2		0.85	10	6	250		20		4	(Note 8)	68
							100	450	10	1												
							100		100	1	0.4		1.0	200								
							100	350	150	5												
PN200	TO-92 (92)	60	45	6	50	50	80		0.1	1	0.2		0.85	10	6	250		20		4	(Note 8)	68
							100	450	10	1												
							100		100	1	0.4		1.0	200								
							100	350	150	5												

General Purpose Amplifiers and Switches (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN200A	TO-92	60	45	6	50	50	300	600	10	1	0.2		0.85	10	6	250		20		4	(Note 8)	68
	(92)						100		100	1												
							250		0.1	5	0.4		1.0	200								
PN201	TO-92	80	65	6	50	60	60		0.1	1	0.2		0.85	10	4.5	100		10		4	(Note 8)	69
	(92)						75	375	10	1												
							50		100	1	0.4		1.0	200								
2N5400	TO-92	130	120	5	100	100	40		50	5	0.2		1.0	10	6	100	400	10		8	(Note 9)	74
	(92)						40	180	10	5												
							30		1	5	0.5		1.0	50								
2N5401	TO-92	160	150	5	50	120	50		50	5	0.2		1.0	10	6	100	300	10		8	(Note 9)	74
	(92)						60	240	10	5												
							50		1	5	0.5		1.0	50								
MPSL51	TO-92	100	100	4	1 μA	50	40	250	50	5	0.25		1.2	10	8	60		10				74
	(92)										0.3		1.2	50								
PN4888	TO-92	150	150	6	50	100	40	400	10	10	0.5		0.9	10	4	30		60				74
	(92)						30		1	10												
PN4889	TO-92	150	150	6	10	100	80	300	10	10	0.5		0.9	10	4	40	160	1		4	(Note 15)	74
	(92)						70		1	10										10	(Note 16)	
							60		0.1	10										3	(Note 17)	
																				3	(Note 18)	

TEST CONDITIONS:

Note 1: I_C = 300 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 30 mA.

Note 2: I_C = 150 mA, V_{CC} = 6V, $I_B^1 = I_B^2$ = 15 mA.

Note 3: I_C = 300 mA, V_{CC} = 15V, $I_B^1 = I_B^2$ = 30 mA.

Note 4: I_C = 300 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 30 mA.

Note 5: I_C = 10 mA, V_{CC} = 3V, $I_B^1 = I_B^2$ = 1 mA.

Note 6: I_C = 100 μA, V_{CE} = 5V, f = 100 Hz.

Note 7: I_C = 30 μA, V_{CE} = 5V, f = 1 kHz.

Note 8: I_C = 100 μA, V_{CE} = 5V, f = 1 kHz.

Note 9: I_C = 250 μA, V_{CE} = 5V, f = 1 kHz.

Note 10: I_C = 10 μA, V_{CE} = 5V, f = 1 kHz.

Note 11: I_C = 50 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 5 mA.

Note 12: I_C = 150 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 15 mA.

Note 13: I_C = 50 mA, V_{CC} = 10V, $I_B^1 = I_B^2$ = 5 mA.

Note 14: I_C = 500 mA, V_{CC} = 30V, $I_B^1 = I_B^2$ = 50 mA.

Note 15: I_C = 100 μA, V_{CC} = 10V, f = 1 kHz.

Note 16: I_C = 200 μA, V_{CE} = 5V, f = 1 kHz.

Note 17: I_C/I_B = 40.

Note 18: I_C/I_B = 20.

National Semiconductor

Medium Power

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N4030	TO-39	60	60	5	50	50	15		1A	5	1.0			1A	20	100	400	50	400		(Note 3)	67
							25		500	5	0.5			500								
							40		100	5	0.15		0.9	150								
							30	120	0.1	5												
2N4031	TO-39	80	80	5	50	60	10		1A	5	0.5			500	20	100	400	50	400		(Note 3)	67
							25		500	5	0.15		0.9	150								
							40	120	100	5												
							30		0.1	5												
2N4032	TO-39	60	60	5	50	50	40		1A	5	1.0			1A	20	150	500	50	400		(Note 3)	67
							70		500	5	0.5			500								
							100	300	100	5	0.15		0.9	150								
							75		0.1	5												
2N4033 also Avail. JAN/TX/V Versions	TO-39	80	80	5	50	60	25		1A	5	0.5			500	20	150	500	50	400		(Note 3)	67
							70		500	5	0.15		0.9	150								
							100	300	100	5												
							75		0.1	5												
2N4036	TO-39	90	85	7	20	60	20		500	10	0.6		1.4	150	30	60		50	700		(Note 4)	67
							40	140	150	10												
							20		0.1	10												
2N4037	TO-39	60	40	7	250	60	50	250	150	10	1.4			150	30	60		50				67
							15		1	10												
2N4314	TO-39	90	65		250	60	50	250	150	10	1.4			150	30	60		50				67
							15		1	10												
2N4354		Same as PN4354																				67
2N4355		Same as PN4355																				67
2N4356		Same as PN4356																				67

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MPSA55	TO-92 (92)		60	4	100	60	50		100	1	0.25			100		50		100				67
							50		10	1												
MPSA56	TO-92 (92)		80	4	100	80	50		100	1	0.25			100		50		100				67
							50		10	1												
MPS4354	TO-92 (92)	Same as PN4354																				67
MPS4355	TO-92 (92)	Same as PN4355																				67
MPS4356	TO-92 (92)	Same as PN4356																				67
MPS6562	TO-92 (92)	25	25	5	100	20	50	200	500	1	0.5			500	30	60		10				67
							50		100	1												
							35		10	1												
PN4354	TO-92 (92)	60	60	5	50	50	30		500	10	0.15		0.9	150	30	100	500	50	400	3	14/15	67
							40		100	10												
							50	500	10	10	0.5		1.1	500								
							40		1	10												
							25		0.1	10												
PN4355	TO-92 (92)	60	60	5	50	50	75		500	10	0.15		0.9	150	30	100	500	50	400	3	14/15	67
							75		100	10												
							100	400	10	10	0.5		1.1	500								
							75		1	10												
							60		0.1	10												
PN4356	TO-92 (92)	80	80	5	50	50	30		500	10	0.15		0.9	150	30	100	500	50	400	3	14/15	67
							40		100	10												
							50	250	10	10	0.5		1.1	500								
							40		1	10												
							25		0.1	10												
PN5855	TO-92 (92)	60	60	5	100	40	50	300	150	10	0.4		1.3	15	15	100		50		4		67
							50		10	10												
							50		500	10												
							15		1A	10												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
PN5857	TO-92	80	80	5	100	60	50	300	150	10	0.4		1.3	15	15	100		50				67
	(92)						50		10	10												
							50		500	10												
							15		1A	10												
TN4033	TO-237	80	80	5	50	60	75		0.1	5	0.15		0.9	150	20	150	500	50				67
	(91)						100	300	100	5	0.5			500								
							70		500	5												
							25		1A	5												
TN4036	TO-237	90	65	7	20	60	20		0.1	10	0.65		1.4	150	30	60	50					67
	(91)						40	140	150	10												
							20		500	10												
TN4037	TO-237	60	40	7	250	60	15		1	10	1.4			150	30	60	200	50				67
	(91)						50	250	150	10												
TN4314	TO-237	90	65		250	60	15		1	10	1.4			150	30	60		50				67
	(91)						50	250	150	10												
MPSA92	TO-92	300	300	5	250	200	25		1	10	0.5		0.9	20	6	50		10				76
	(92)						40		10	10												
							25		30	10												
MPSA93	TO-92	200	200	5	250	160	25		1	10	0.4		0.9	20	8	50		10				76
	(92)						40		10	10												
							25	150	30	10												
MPSW92	TO-92	200	200	5	250	200	25		1	10	0.5		0.9	20	6	50		10				76
	(99)						40		10	10												
							25		30	10												
2N6726	TO-237	40	30	5	100	40	55		10	1	0.5			1A		50		50				77
	(91)						60		100	1												
							50	200	1A	1												
2N6727	TO-237	50	40	5	100	50	55		10	1	0.5			1A		50	500	50				77
	(91)						80		100	1												
							50	250	1A	1												
92PU51	TO-237		30		100	40	50		1A	1	0.5			1A	30	50		50				77
	(91)						60		100	1												
							55		10	1												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
92PU51A	TO-237		40		100	50	50		1A	1	0.5			1A	30	80		50				77
	(91)						60		100	1												
							55		10	1												
NSD202	TO-202	60	45	5	100	60	25		1A	5	0.2		0.9	100	30	60		50				77
	(55)						40		500	5												
							50	150	100	5												
							40		10	5	0.4		1.2	500								
NSD203	TO-202	60	45	5	100	60	30		1A	5	0.2		0.9	100	30	60		50				77
	(55)						50		500	5												
							120	360	100	5												
							50		10	5	0.4		1.2	500								
NSDU51	TO-202	40	30	5	100	30	50		1A	1	0.7			1A	30	50		50				77
	(55)						60		100	1												
							55		10	1												
NSDU51A	TO-202	50	40	5	100	40	50		1A	1	0.7			1A	30	50		50				77
	(85)						60		100	1												
							55		10	1												
D41D1	TO-202		30		100*	45	10		1A	2	0.5		1.5	500								78
	(55)						50	150	100	2												
D41D2	TO-202		30		100*	45	20		1A	2	0.5		1.5	500								78
	(55)						120	300	100	2												
D41D4	TO-202		45		100*	60	10		1A	2	0.5		1.5	500								78
	(55)						50	150	100	2												
D41D5	TO-202		45		100*	60	20		1A	2	0.5		1.5	500								78
	(55)						120	360	100	2												
D41D7	TO-202		60		100*	75	10		1A	2	1.0		1.5	500								78
	(55)						50	150	100	2												
D41D8	TO-202		60		100*	75	20		1A	2	1.0		1.5	500								78
	(55)						120	360	100	2												
D41D10	TO-202		75		100*	90	10		1A	2	1.0		1.5	500								78
	(55)						50	150	100	2												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
D41D11	TO-202 (55)		75		100*	90	20		1A	2	1.0		1.5	500								78
							120	360	100	2												
D41D13	TO-202 (55)		75		100*	90	50	150	100	2	1.0		1.5	500								78
D41D14	TO-202 (55)		75		100*	90	120	360	100	2	1.0		1.5	500								78
D41E1	TO-202 (55)		30		100*	40	10		1A	2	1.0		1.3	1A								78
							50		100	2												
D41E5	TO-202 (55)		60		100*	70	10		1A	2	1.0		1.3	1A								78
							50		100	2												
D41E7	TO-202 (55)		80		100*	90	10		1A	2	1.0		1.3	1A								78
							50		100	2												
NSDU52	TO-202 (55)	60	40	5	100	40	30		500	10	0.4		1.3	150	20	150		20				78
							50	300	150	10												
							50		10	10												
2N6554	TO-202 (55)	60	60	5	100	40	25		500	1	1.0			1A	18	75	250	100				78
							60		250	1												
							80	300	50	1												
							80		10	1	0.5			250								
2N6555	TO-202 (55)	60	60	5	100	60	25		500	1	1.0			1A	18	78	250	100				78
							60		250	1												
							80	300	50	1												
							60		10	1	0.8			250								
2N6556	TO-202 (55)	100	100	5	100	80	25		500	1	1.0			1A	18	75	250	100				78
							60		250	1												
							80	300	50	1												
							60		10	1	0.5			250								

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
2N6706	TO-237	60	45	5	100	60	40		50	2	1.0			1A		50		50				78
	(90)						40	250	250	2												
							25		500	2	0.5			500								
2N6709	TO-237	80	60	5	100	80	40		50	2	1.0			1A		50		50				78
	(90)						40	250	250	2												
							25		500	2	0.5			500								
2N6710	TO-237	100	80	5	100	100	40		50	2	1.0			1A		50		50				78
	(90)						40	250	250	2												
							25		500	2	0.5			500								
MPS6727	TO-92	50	40	5	100	50	60		100	1	0.5		1.2	1A	30							78
	(99)						50	250	1A	1												
NSD6180	TO-202		75		500	80	10		1A	2	0.5		1.2	500	30	50		50				78
	(55)						40	250	500	2												
							30		50	2												
NSD6181	TO-202		50		500	60	10		1A	2	0.5		1.2	500	30	50		50				78
	(55)						40	250	500	2												
							30		50	2												
NSDU55	TO-202	60	60	4	100	60	20		500	1	0.35			250	30	50		200				78
	(55)						50		250	1												
							80		50	1												
PE8550	TO-92	30	25	6	100	20	50	200	10	1	0.15		0.9	200	40	100		50				78
	(92)						65	200	100	1												
							65	200	500	1												
							40	200	1A	1	0.5		1.2	1A								
TN4234	TO-237	40	40	7	0.1 mA	40	40		100	1	0.6		1.5	1A	100							78
	(91)						30	150	250	1												
							20		500	1												
							10		1A	1												
TN4235	TO-237	60	60	7	0.1 mA	60	40		100	1	0.6		1.5	1A	100							78
	(91)						30	150	250	1												
							20		500	1												
							10		1A	1												

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
TN4236	TO-237	80	80	7	0.1 mA	80	40		100	1	0.6		1.5	1A	100							78
	(91)						30	150	250	1												
							20		500	1												
							10		1A	1												
2N6728	TO-237	60	60	5	100	40	80		50	1	0.35			250		50		50				79
	(91)						50	250	250	1												
							20		500	1												
2N6729	TO-237	80	80	5	100	60	80		50	1	0.35			250		50		50				79
	(91)						50	250	250	1												
							20		500	1												
2N6730	TO-237	100	100	5	100	80	80		50	1	0.35			250		50		50				79
	(91)						50	250	250	1												
							20		500	1												
2N6732	TO-237	100	80	5	100	80	100		10	2	0.35			350		50		50				79
	(91)						100	300	350	2												
92PU55	TO-237		60		100	40	20		500	1	0.35			250	30	50		200				79
	(91)						50		250	1												
							80		50	1												
92PU56	TO-237		80		100	60	20		500	1	0.35			250	30	50		200				79
	(91)						50		250	1												
							80		50	1												
92PU57	TO-237		100		100	80	20		500	1	0.35			250	30	50		200				79
	(91)						50		250	1												
							80		50	1												
NSD204	TO-202	100	80	7	100	100	10		1A	5	0.2		0.9	100	30	60		50				79
	(55)						50	150	100	5												
							20		10	5	0.5		1.2	500								
NSD205	TO-202	100	80	7	100	100	10		1A	5	0.2		0.9	100	30	60		50				79
	(55)						120	360	100	5												
							20		10	5	0.5		1.2	500								

Medium Power (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{OFF} (ns) Max	NF (dB) Max	Test Conditions	Process No.
NSD206	TO-202	140	100	7	100	140	25		500	5	0.2		0.9	100	30	60		50				79
	(55)						50	150	100	5												
							20		10	5	0.5		1.2	500								
NSDU56	TO-202	80	80	4	100	80	20		500	1	0.35			250	30	50		200				79
	(55)						50		250	1												
							80		50	1												
NSDU57	TO-202	100	100	4	100	100	20		500	1	0.35			250	30	50		200				79
	(55)						50		250	1												
							80		50	1												

TEST CONDITIONS:

Note 1: $I_C = 50$ mA, $V_{CC} = 100V$, $I_B{}^1 = I_B{}^2 = 5$ mA.

Note 2: $I_C = 500\ \mu A$, $V_{CE} = 10V$, $f = 1$ kHz.

Note 3: $I_C = 500$ mA, $I_B{}^1 = I_B{}^2 = 50$ mA.

Note 4: $I_C = 150$ mA, $V_{CC} = 30V$, $I_B{}^1 = I_B{}^2 = 15$ mA.

Note 5: $I_C = 100\ \mu A$, $V_{CC} = 10V$, $f = 1$ kHz.

Note 6: $I_C = 500$ mA, $V_{CC} = 30V$, $I_B{}^1 = I_B{}^2 = 50$ mA.

Note 7: $I_C/I_B = 8$.

National Semiconductor

Darlington Transistors

Type No.	Case Style	V_{CBO} (V) Min	V_{CES}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CEX}† (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{OB} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D41K1	TO-202 (55)		30*	13	0.5	30	10,000 1000		0.2 1.5	5 5	1.5		2.5	1.5		100		0.02	61
D41K2	TO-202 (55)		50*	13	0.5	50	10,000 1000		0.2 1.5	5 5	1.5		2.5	1.5		100		0.02	61
D41K3	TO-202 (55)		30*	13	0.5	30	10,000 1000		0.2 1.5	5 5	1.5		2.5	1		100		0.02	61
D41K4	TO-202 (55)		50*	13	0.5	50	10,000 1000		0.2 1.5	5 5	1.5		2.5	1		100		0.02	61
MPSA62	TO-92 (92)		20*		0.1	15	20,000		10	5	1.0			10				0.01	61
MPSA63	TO-92 (92)		30*		0.1	30	10,000 5000		100 10	5 5	1.5			100		125		0.01	61
MPSA64	TO-92 (92)		30*		0.1	30	20,000 10,000		100 10	5 5	1.5			100		125		0.01	61
MPSA65	TO-92 (92)		30*		0.1	30	50,000 20,000		0.01 0.1	5 5	1.5					100		0.01	61
MPSA66	TO-92 (92)		30*		0.1	30	75,000 40,000		0.01 0.1	5 5	1.5					100		0.01	61
MPSW63	TO-226 (99)		30*		0.1	30	10,000 5000		100 10	5 5	1.5			100		125		0.01	61
MPQA63	TO-116		30*		0.1	30	10,000 5000		100 10	5 5	1.5			100		125		0.01	61
NSDU95	TO-202 (55)	50		10			25,000 15,000 4000		0.2 0.5 1	5 5 5	1.5			1		50		0.02	61
NSDU95A	TO-202 (55)	60		10			25,000 15,000 4000		0.2 0.5 1	5 5 5	1.5			1		50		0.02	61

Section 5
JFET Transistors

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National Semiconductor

N-Channel JFETs

Switches/Choppers

Type No.	Case Style	BVGSS BVGDO (V) Min	@ IG (μA)	IGSS *IDGO (nA) Max	@ VDG (V)	ID(off) (nA) Max	@ VDS (V)	VGS (V)	VP (V) Min	VP (V) Max	@ VDS (V)	ID (nA)	IDSS (mA) Min	IDSS (mA) Max	@ VDS (V)	rds(on) (Ω) Max	@ ID (mA)	Ciss (pF) Max	@ VDS (V)	VGS (V)	Crss (pF) Max	@ VDS (V)	VGS (V)	ton (ns) Max	toff (ns) Max	Process No.	Pkg. No.
2N3824	TO-72	50	1	0.1	30	0.1	15	−8		8	15	0.1				250		6	15	0	3	0	−8			55	25
2N3966	TO-72	30	1	1	20	0.1	10	−7	4	6	10	10	2		20	220		6	20	0	1.5	0	−7			50	25
2N3970	TO-18	40	1	0.25*	20	0.25	20	−12	4	10	20	1	50	150	20	30	1	25	20	0	6	0	−12	20	30	51	02
2N3971	TO-18	40	1	0.25*	20	0.25	20	−12	2	5	20	1	25	75	20	60	1	25	20	0	6	0	−12	30	60	51	02
2N3972	TO-18	40	1	0.25*	20	0.25	20	−12	0.5	3	20	1	5	30	20	100	1	25	20	0	6	0	−12	80	100	51	02
2N4091	TO-18	40	1	0.2*	20	0.2	20	−12	5	10	20	1	30		20	30	1	16	20	0	5	0	−20	25	40	51	02
2N4092	TO-18	40	1	0.2*	20	0.2	20	−8	2	7	20	1	15		20	50	1	16	20	0	5	0	−20	35	60	51	02
2N4093	TO-18	40	1	0.2*	20	0.2	20	−6	1	5	20	1	8		20	80	1	16	20	0	5	0	−20	60	80	51	02
2N4391	TO-18	40	1	0.1	20	0.1	20	−12	4	10	20	1	50	150	20	30	1	14	20	0	3.5	0	−12	20	35	51	02
2N4392	TO-18	40	1	0.1	20	0.1	20	−7	2	5	20	1	25	75	20	60	1	14	20	0	3.5	0	−7	20	55	51	02
2N4393	TO-18	40	1	0.1	20	0.1	20	−5	0.5	3	20	1	5	30	20	100	1	14	20	0	3.5	0	−5	20	80	51	02
2N4856	TO-18	40	1	0.25	20	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	02
2N4856A	TO-18	40	1	0.25	20	0.25	15	−10	4	10	15	0.5	50		15	25		10	0	−10	4	0	−10	9	20	51	02
2N4857	TO-18	40	1	0.25	20	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	02
2N4857A	TO-18	40	1	0.25	20	0.25	15	−10	2	6	15	0.5	20	100	15	40		10	0	−10	3.5	0	−10	10	40	51	02
2N4858	TO-18	40	1	0.25	20	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	02
2N4858A	TO-18	40	1	0.25	20	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		10	0	−10	3.5	0	−10	16	80	51	02
2N4859	TO-18	30	1	0.25	15	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	02
2N4859A	TO-18	30	1	0.25	15	0.25	15	−10	4	10	15	0.5	50		15	25		10	0	−10	4	0	−10	8	20	51	02
2N4860	TO-18	30	1	0.25	15	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	02
2N4860A	TO-18	30	1	0.25	15	0.25	15	−10	2	6	15	0.5	20	100	15	40		10	0	−10	3.5	0	−10	10	40	51	02
2N4861	TO-18	30	1	0.25	15	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	02
2N4861A	TO-18	30	1	0.25	15	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		10	0	−10	3.5	0	−10	16	80	51	02
2N5432	TO-52	25	1	0.2	15	0.2	5	−10	4	10	5	3	150		15	5	10	30	0	−10	15	0	−10	5	36	58	07
2N5433	TO-52	25	1	0.2	15	0.2	5	−10	3	9	5	3	100		15	7	10	30	0	−10	15	0	−10	5	36	58	07
2N5434	TO-52	25	1	0.2	15	0.2	5	−10	1	4	5	3	30		15	10	10	30	0	−10	15	0	−10	5	36	58	07
2N5555	TO-92	25	10	1	15	10	12	−10		(10)			15		15	150		5	15	0	1.2	0	−10	10	25	50	92
2N5638	TO-92	30	10	1	15	1	15	−12		(12)			50		20	30	1	10	0	−12	4	0	−12			51	92
2N5639	TO-92	30	10	1	15	1	15	−8		(8)			25		20	60	1	10	0	−12	4	0	−8			51	92
2N5640	TO-92	30	10	1	15	1	15	−6		(6)			5		20	100	1	10	0	−12	4	0	−6			51	92

Switches/Choppers (Continued)

N-Channel JFETs

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) @	I_G	I_{GSS} $^*I_{DGO}$ (nA) @	V_{DG}	$I_{D(off)}$ (nA) @	V_{DS}	V_{GS}	V_P (V) @		V_{DS}	I_D	I_{DSS} (mA) @		V_{DS}	$r_{ds(on)}$ (Ω) @	I_D	C_{iss} (pF) @	V_{DS}	V_{GS}	C_{rss} (pF) @	V_{DS}	V_{GS}	t_{on}	t_{off}	Process No.	Pkg. No.
		Min	(µA)	Max	(V)	Max	(V)	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Max	(mA)	Max	(V)	(V)	Max	(V)	(V)	(ns) Max	(ns) Max		
2N5653	TO-92	30	10	1	15	1	15	−12		(12)			40		20	50	1	10	0	−12	3.5	0	−12	9	15	51	92
2N5654	TO-92	25	10	1	15	10	15	−8		(8)			15		20	100	1	10	0	−12	3.5	0	−8	14	30	51	92
J105	TO-92	25	1	3	15	3	5	10	4.5	10	5	1000	500		15	3	33									59	92
J106	TO-92	25	1	3	15	3	5	10	2	6	5	1000	200		15	6	17									59	92
J107	TO-92	25	1	3	15	3	5	10	0.5	4.5	5	1000	100		15	8	13									59	92
J108	TO-92	25	1	3	15	3	5	−10	3	10	5	1000	80		15	8	10									58	92
J109	TO-92	25	1	3	15	3	5	−10	2	6	5	1000	40		15	12	10									58	92
J110	TO-92	25	1	3	15	3	5	−10	0.5	4	5	1000	10		15	18	10									58	92
J111	TO-92	35	1	1	15	1	5	−10	3	10	5	1000	20		15	30	1									51	92
J112	TO-92	35	1	1	15	1	5	−10	1	5	5	1000	5		15	50	1									51	92
J113	TO-92	35	1	1	15	1	5	−10	0.5	3	5	1000	2		15	100	1									51	92
J114	TO-92	25	1	1	15	1	5	−10	3	10	5	1000	15		15	150	1									90	92
PN4091	TO-92	40	1	0.2*	20	0.2	20	−12	5	10	20	1	30		20	30		16	20	0	5	20	0	25	40	51	92
PN4092	TO-92	40	1	0.2*	20	0.2	20	−8	2	7	20	1	15		20	50		16	20	0	5	20	0	35	60	51	92
PN4093	TO-92	40	1	0.2*	20	0.2	20	−6	1	5	20	1	8		20	80		16	20	0	5	20	0	60	80	51	92
PN4391	TO-92	40	1	0.1	20	0.1	20	−12	4	10	20	1	50	150	20	30		14	20	0	3.5	0	−12	20	35	51	92
PN4392	TO-92	40	1	0.1	20	0.1	20	−7	2	5	20	1	25	75	20	60		14	20	0	3.5	0	−7	40	80	51	92
PN4393	TO-92	40	1	0.1	20	0.1	20	−5	0.5	3	20	1	5	30	20	100		14	20	0	3.5	0	−5	55	130	51	92
PN4856	TO-92	40	1	0.25	20	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	92
PN4857	TO-92	40	1	0.25	20	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	92
PN4858	TO-92	40	1	0.25	20	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	92
PN4859	TO-92	30	1	0.25	15	0.25	15	−10	4	10	15	0.5	50		15	25		18	0	−10	8	0	−10	9	25	51	92
PN4860	TO-92	30	1	0.25	15	0.25	15	−10	2	6	15	0.5	20	100	15	40		18	0	−10	8	0	−10	10	50	51	92
PN4861	TO-92	30	1	0.25	15	0.25	15	−10	0.8	4	15	0.5	8	80	15	60		18	0	−10	8	0	−10	20	100	51	92
PN5432	TO-92	25	1	0.2	15	0.2	5	−10	4	10	5	3	150		15	5	10	30	0	−10	15	0	−10	5	36	58	92
PN5433	TO-92	25	1	0.2	15	0.2	5	−10	3	9	5	3	100		15	7	10	30	0	−10	15	0	−10	5	36	58	92
PN5434	TO-92	25	1	0.2	15	0.2	5	−10	1	4	5	3	30		15	10	10	30	0	−10	15	0	−10	5	36	58	92
TIS73	TO-92	30	1	2	15	2	15	−10	4	10	15	4	50		15	25		18	0	−10	8	0	−10	9	25	51	97
TIS74	TO-92	30	1	2	15	2	15	−10	2	6	15	4	20	100	15	40		18	0	−10	8	0	−10	10	50	51	97
TIS75	TO-92	30	1	2	15	2	15	−10	0.8	4	15	4	8	80	15	60		18	0	−10	8	0	−10			51	97
U1897	TO-92	40	1	0.2*	20				5	10	20	1	30		20	30	1	16	20	0	5	0	−20	25	40	51	92
U1898	TO-92	40	1	0.2*	20				2	7	20	1	15		20	50	1	16	20	0	5	0	−20	35	60	51	92
U1899	TO-92	40	1	0.2*	20				1	5	20	1	8		20	80	1	16	20	0	5	0	−20	60	80	51	92

National Semiconductor

N-Channel JFETs

RF, VHF, UHF Amplifiers

Type No.	Case Style	BV_{GSS} (V) @ I_G		I_{GSS} (nA) @ V_{DG}		VP (V) @ V_{DS}			I_D	I_{DSS} (mA) @ V_{DS}			$R_e\|Y_{fs}\|$ (mmho) @ Freq.		$R_e(Y_{os})$ (μmho) @ f		C_{iss} (pF) @ V_{DS}		V_{GS}	C_{rss} (pF) @ V_{DS}		V_{GS}	NF (dB) @ R_G = 1k		Process No.	Pkg. No.
		Min	(μA)	Max	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Min	(MHz)	Max	(MHz)	Max	(V)	(V)	Max	(V)	(V)	Max	Freq. (MHz)		
2N3819	TO-92	25	1	2	15		8	15	2	2	20	15	1.6	100			8	15	0	4	15	0			50	94
2N3823	TO-72	30	1	0.5	20		8	15	0.5	4	20	15	3.2	200	200	200	6	15	0	2	15	0	2.5	100	50	25
2N4223	TO-72	30	10	0.25	20	0.1	8	15	0.25	3	18	15	2.7	200	200	200	6	15	0	2	15	0	5	200	50	25
2N4224	TO-72	30	10	0.5	20	0.1	8	15	0.5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	25
2N4416	TO-72	30	1	0.1	20		6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N4416A	TO-72	35	1	0.1	20	2.5	6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N5078	TO-72	30	1	0.25	20	0.5	8	15		4	25	15	4	200	150	200	6	15	0	2	15	0	3	200	50	25
2N5245	TO-92	30	1	1	20	1	6	15	10	5	15	15	4	400	100	400	4.5	15	0	1	15	0	4	400	90	97
2N5246	TO-92	30	1	1	20	0.5	4	15	10	1.5	7	15	2.5	400	100	400	4.5	15	0	1	15	0			90	97
2N5247	TO-92	30	1	1	20	1.5	8	15	10	8	24	15	4	400	150	400	4.5	15	0	1	15	0			90	97
2N5248	TO-92	30	1	5	20	1	8	15	10	4	20	15	3	200	200	200	6	15	0	2	15	0			50	94
2N5397	TO-72	25	1	0.1	15	1	6	10	1	10	30	10	5.5	450	200	450	5	10	10 mA	1.2	10	10 mA	3.5	450	90	29
2N5398	TO-72	25	1	0.1	15	1	6	10	1	5	40	10	5.0	450	400	450	5.5	10	0	1.3	10	0	3.2	450	90	29
2N5484	TO-92	25	1	1	20	0.3	3	15	10	1	5	15	2.5	100	75	100	5	15	0	1	15	0	3	100	50	92
2N5485	TO-92	25	1	1	20	1	4	15	10	4	10	15	3	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5486	TO-92	25	1	1	20	2	6	15	10	8	20	15	3.5	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5468	TO-92	25	10	2	15	0.2	4	14	10	1	5	15	1	100	50	100	7	15	0	3	15	0	2.5	100	50	92
2N5469	TO-92	25	10	2	15	1	6	15	10	4	10	15	1.6	100	100	100	7	15	0	3	15	0	2.5	100	50	92
2N5470	TO-92	25	10	2	15	2	8	15	10	8	20	15	2.5	100	150	100	7	15	0	3	15	0	2.5	100	50	92
2N5949	TO-92	30	1	1	15	3	7	15	100	12	18	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5950	TO-92	30	1	1	15	2.5	6	15	100	10	15	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5951	TO-92	30	1	1	15	2	5	15	100	7	13	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5952	TO-92	30	1	1	15	1.3	3.5	15	100	4	8	15	1.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5953	TO-92	30	1	1	15	0.8	3	15	100	2.5	5	15	1.0	100	50	100	6	15	0	2	15	0	5	100	50	97
J300	TO-92	25	1	0.5	15	1	6	10	1	6	30	10	4.5	0.001	200	0.001	5.5	10	5 mA	1.7	10	5 mA			90	92
J304	TO-92	30	1	0.1	20	2	6	15	1	5	15	15	t4.2	400	t80	100									50	92
J305	TO-92	30	1	0.1	20	0.5	3	15	1	1	8	15	t3.0	400	t80	100									50	92
J308	TO-92	25	1	1	15	1	6.5	10	1	12	60	10	8	0.001	200	0.001	7.5	0	−10	2.5	0	−10			92	92
J309	TO-92	25	1	1	15	1	4.0	10	1	12	30	10	10	0.001	200	0.001	7.5	0	−10	2.5	0	−10			92	92
J310	TO-92	25	1	1	15	2	6.5	10	1	24	60	10	8	0.001	200	0.001	7.5	0	−10	2.5	0	−10			92	92

t = typical value

RF, VHF, UHF Amplifiers (Continued)

N-Channel JFETs

Type No.	Case Style	BV_{GSS} (V) Min	@ I_G (μA)	I_{GSS} (nA) Max	@ V_{DG} (V)	VP (V) Min	VP (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	$R_e\|Y_{fs}\|$ (mmho) Min	@ Freq. (MHz)	$R_e(Y_{os})$ (μmho) Max	@ f (MHz)	C_{iss} (pF) Max	@ I_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	NF (dB) @ R_G = 1k Max	Freq. (MHz)	Process No.	Pkg. No.
MPF102	TO-92	25	1	2	15		8	15	2	2	20	15	1.6	100	100	200	7	15	0	3	15	0			50	92
MPF106	TO-92	25	1	1	20	0.5	4	15	0.5	4	10	15	2.5	0.001			5	15	0	2	15	0	4	400	50	92
MPF107	TO-92	25	1	1	20	2	6	15	0.5	8	20	15	4	0.001			5	15	0	1.2	15	0	4	400	50	92
MPF108	TO-92	25	10	1	15	0.5	8	15	10	1.5	24	15	1.6	100	200	100	6.5	15	0	2.5	15	0	3	100	50	92
MPF256	TO-92	25	10	5	15	0.5	7.5	15	200μ	3	18	15	6	0.001									2.0	100	90	92
MPF820	TO-92	25	10	5	15		5.0	15	200μ	10		15		0.001									4.0	100	51	92
PN4223	TO-92	30	1	0.25	20	0.1	8	15	1	3	18	15	2.7	200	200	200	6	15	0	2	15	0	5	200	50	92
PN4224	TO-92	30	1	0.5	20	0.1	8	15	5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	92
PN4416	TO-92	30	1	0.1	20		6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	92
U308	TO-52	25	1	0.15	15	1	6	10	1	12	60	10	10	0.001	150	100	5	0	10 mA	2.5	0	10 mA			92	07
U309	TO-52	25	1	0.15	15	1	4	10	1	12	30	10	10	0.001	150	100	5	0	10 mA	2.5	0	10 mA			92	07
U310	TO-52	25	1	0.15	15	2.5	6	10	1	24	60	10	10	0.001	150	100	5	10	10 mA	2.5	10	10 mA			92	07
U312	TO-52	25	1	0.1	15	1	6	10	1	10	30	10	6	0.001			3.8	10	10 mA	1.2	10	10 mA			90	07

National Semiconductor

N-Channel JFETs

Low Frequency—Low Noise Amplifiers

Type No.	Case Style	BV_{GSS} (V) Min	I_G (μA)	I_{GSS} (nA) Max	V_{DG} (V)	$V_{GS(off)}$ (V) Min	$V_{GS(off)}$ (V) Max	V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	V_{DS} (V)	g_{fs} ($R_e\|Y_{fs}$) (mmho) Min	g_{fs} ($R_e\|Y_{fs}$) (mmho) Max	V_{DS} (V)	f (MHz)	G_{oss} (μmho) Max	V_{DS} (V)	C_{iss} (pF) Max	V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	V_{DS} (V)	e_n nV/$\sqrt{Hz}$ Max	@ f (Hz)	Process No.	Pkg. No.
2N4393	TO-18	40	1.0	0.1	20	0.5	3.0	20	1.0	5	30	20	t12		20	0.001			14	20	0	3.5	5(GS)	t8	10	51	02
2N5556	TO-72	30	10	0.1	15	0.2	4.0	15	1.0	0.5	2.5	15	1.5	6.5	15	0.001	20	15	6	15	0	3	15	35	10	50	25
2N5557	TO-72	30	10	0.1	15	0.8	5.0	15	1.0	2	5.0	15	1.5	6.5	15	0.001	20	15	6	15	0	3	15	35	10	50	25
2N5558	TO-72	30	10	0.1	15	1.5	6.0	15	1.0	4	10	15	1.5	6.5	15	0.001	20	15	6	15	0	3	15	35	10	50	25
NF5101	TO-72	40	1	0.2	15	0.5	1.1	15	1.0	1	12	15	3.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	25
NF5102	TO-72	40	1	0.2	15	0.7	1.6	15	1.0	4	20	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	25
NF5103	TO-72	40	1	0.2	15	1.2	2.7	15	1.0	10	40	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	25
PF5101	TO-92	40	1	0.2	15	0.5	1.1	15	1.0	1	12	15	3.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PF5102	TO-92	40	1	0.2	15	0.7	1.6	15	1.0	4	20	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PF5103	TO-92	40	1	0.2	15	1.2	2.7	15	1.0	10	40	15	7.5		15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PN4393	TO-92	40	1	0.1	20	0.5	3.0	20	1.0	5	30	20	t12		20	0.001			14	20	0	3.5	5(GS)	t8	10	51	92

t = typical value.

National Semiconductor

N-Channel JFETs

Ultra Low Input Current Amplifiers

Type No.	Case Style	BV_{GSS} (V) @	I_G	I_{GSS} (pF) @	V_{DG}	V_P (V)	@	V_{DS}	I_D	I_{DSS} (μA @ V_{DS})			G_{fs} (μmho) @ V_{DS}			G_{oss} (μmho)	V_{DS}	C_{iss} (pF) @	V_{DS}	V_{GS}	C_{rss} (pF) @	V_{DS}	V_{GS}	Process No.	Pkg. No.
		Min	(μA)	Max	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Min	Max	(V)	Max	(V)	Max	(V)	(V)	Max	(V)	(V)		
2N4117	TO-72	40	1	10	20	0.6	1.8	10	1	30	90	10	20	210	10	3	10	3	10	0	1.5	10	0	53	25
2N4117A	TO-72	40	1	1	20	0.6	1.8	10	1	30	90	10	70	210	10	3	10	3	10	0	1.5	10	0	53	25
2N4118	TO-72	40	1	10	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	25
2N4118A	TO-72	40	1	1	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	25
2N4119	TO-72	40	1	10	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	25
2N4119A	TO-72	40	1	1	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	25
NF5301	TO-72	30	1	1	15	0.6	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-1	TO-72	30	1	1	15	0.6	1.8	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-2	TO-72	30	1	1	15	1.7	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-3	TO-72	30	1	1	15	1.0	2.4	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
PF5301	TO-92	30	1	1	15	0.6	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-1	TO-92	30	1	1	15	0.6	1.8	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-2	TO-92	30	1	1	15	1.7	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-3	TO-92	30	1	1	15	1.0	3.4	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PN4117	TO-92	40	1	10	20	0.6	2.8	10	1	30	90	10	20	210	10	3	10	3	10	0	1.5	10	0	53	92
PN4117A	TO-92	40	1	1	20	0.6	2.8	10	1	30	90	10	70	210	10	3	10	3	10	0	1.5	10	0	53	92
PN4118	TO-92	40	1	10	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	92
PN4118A	TO-92	40	1	1	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	92
PN4119	TO-92	40	1	10	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	92
PN4119A	TO-92	40	1	1	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	92
PN4120	TO-92	40	1	20	20	0.6	3	10	1	30	300	10	70	300	10	20	10	3	10	0	1.5	10	0	53	92
PN4120A	TO-92	40	1	5	20	0.6	3	10	1	30	300	10	70	300	10	20	10	3	10	0	1.5	10	0	53	92

National Semiconductor

N-Channel JFETs

General Purpose Amplifiers

Type No.	Case Style	BV_{GSS} $*BV_{GDO}$ (V) @	I_G	I_{GSS} (nA) @	V_{DG}	V_P (V) @		V_{DS}	I_D	I_{DSS} (mA) @		V_{DS}	G_{fs} (mmho) @		V_{DS}	G_{oss} (μmho) @	V_{DS}	C_{iss} (pF) @	V_{DS}	V_{GS}	C_{rss} (pF) @	V_{DS}	V_{GS}	e_n $\left(\frac{NV}{\sqrt{Hz}}\right)$ @	Freq.	Process No.	Pkg. No.
		Min	(μA)	Max	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Min	Max	(V)	Max	(V)	Max	(V)	(V)	Max	(V)	(V)	Max	(Hz)		
2N3369	TO-18	40	1	5	30		6.5	20	1000	0.5	2.5	30	0.6	2.5	30	30	30	20	8	0	3	30	0			52	02
2N3370	TO-18	40	1	5	30		3.2	20	1000	0.1	0.6	30	0.3	2.5	30	15	30	20	8	0	3	30	0			52	02
2N3458	TO-18	50	1	0.25	30		7.8	20	1000	3	15	20	2.5	10	20	35	30	18	0	−10	5	30	0	225	20	52	02
2N3459	TO-18	50	1	0.25	30		3.4	20	1000	0.8	4	20	1.5	6	20	20	30	18	0	−6	5	30	0	155	20	52	02
2N3460	TO-18	50	1	0.25	30		1.8	20	1000	0.2	1	20	0.8	4.5	20	5	30	18	0	−4	5	30	0	155	20	52	02
2N3684	TO-72	50	1	0.1	30	2	5	20	1	2.5	7.5	20	2	3	20	50	20	4	20	0	1.2	20	0	150	100	52	25
2N3685	TO-72	50	1	0.1	30	1	3.5	20	1	1	3	20	1.5	2.5	20	25	20	4	20	0	1.2	20	0	150	100	52	25
2N3686	TO-72	50	1	0.1	30	0.6	2	20	1	0.4	1.2	20	1	2	20	10	20	4	20	0	1.2	20	0	150	100	52	25
2N3687	TO-72	50	1	0.1	30	0.3	1.2	20	1	0.1	0.5	20	0.5	1.5	20	5	20	4	20	0	1.2	20	0	150	100	52	25
2N3821	TO-72	50	1	0.1	30		4	15	0.5	0.5	2.5	15	1.5	4.5	15	10	15	6	15	0	3	15	0	200	10	55	25
2N3822	TO-72	50	1	0.1	30		6	15	0.5	2	10	15	3	6.5	15	20	15	6	15	0	3	15	0	200	10	55	25
2N3967	TO-72	30	1	0.1	20	2	5	20	1	2.5	10	20	2.5		20	35	20□	5	20	□	1.3	20	■	84	100	55	25
2N3967A	TO-72	30	1	0.1	20	2	5	20	1	2.5	10	20	2.5		20	35	20□	5	20	□	1.3	20	■	160	10	55	25
2N3968	TO-72	30	1	0.1	20		3	20	1	1	5	20	2		20	15	20**	5	20	**	1.3	20	†	84	100	55	25
2N3968A	TO-72	30	1	0.1	20		3	20	1	1	5	20	2		20	15	20**	5	20	**	1.3	20	†	160	10	55	25
2N3969	TO-72	30	1	0.1	20		1.7	20	1	0.4	2	20	1.3		20	5	20††	5	20	††	1.3	20	□	84	100	55	25
2N3969A	TO-72	30	1	0.1	20		1.7	20	1	0.4	2	20	1.3		20	5	20††	5	20	††	1.3	20	□	160	10	55	25
2N4220	TO-72	30	10	0.1	15		4	15	0.1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0			55	25
2N4220A	TO-72	30	10	0.1	15		4	15	0.1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0	115	100	55	25
2N4221	TO-72	30	10	0.1	15		6	15	0.1	2	6	15	2	5	15	20	15	6	15	0	2	15	0			55	25
2N4221A	TO-72	30	10	0.1	15		6	15	0.1	2	6	15	2	5	15	20	15	6	15	0	2	15	0	115	100	55	25
2N4222	TO-72	30	10	0.1	15		8	15	0.1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0			55	25
2N4222A	TO-72	30	10	0.1	15		8	15	0.1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0	115	100	55	25
2N4338	TO-18	50	1	0.1	30	0.3	1	15	100	0.2	0.6	15	0.6	1.8	15	5	15	7	15	0	3	15	0	68	1000	52	02
2N4339	TO-18	50	1	0.1	30	0.6	1.8	15	100	0.5	1.5	15	0.8	2.4	15	15	15	7	15	0	3	15	0	68	1000	52	02
2N4340	TO-18	50	1	0.1	30	1	3	15	100	1.2	3.6	15	1.3	3	15	30	15	7	15	0	3	15	0	68	1000	52	02
2N4341	TO-18	50	1	0.1	30	2	6	15	100	3	9	15	2	4	15	60	15	7	15	0	3	15	0	68	1000	55	02
2N5103	TO-72	25	10	0.1	15	0.5	4	15	1	1	8	15	2	8	15	100	15	5	15	0	1	15	0	100	10	50	25
2N5104	TO-72	25	1	0.1	15	0.5	4	15	1	2	6	15	3.5	7.5	15	100	15	5	15	0	1	15	0	50	10	50	25

■I_D = 1 mA; †I_D = 500 μA; ††I_D = 40 μA; **I_D = 100 μA; □I_D = 250 μA.

General Purpose Amplifiers (Continued)

N-Channel JFETs

Type No.	Case Style	BV_{GSS} $^*BV_{GDO}$ (V) @ I_G		I_{GSS} (nA) @ V_{DG}		V_P (V) @ V_{DS}			I_D	I_{DSS} (mA) @ V_{DS}			G_{fs} (mmho) @ V_{DS}			G_{oss} (μmho) @ V_{DS}		C_{iss} (pF) @ V_{DS}		V_{GS}	C_{rss} (pF) @ V_{DS}		V_{GS}	$\left(\frac{NV}{\sqrt{Hz}}\right)^{e_n}$ @ Freq.		Process No.	Pkg. No.
		Min	(μA)	Max	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Min	Max	(V)	Max	(V)	Max	(V)	(V)	Max	(V)	(V)	Max	(Hz)		
2N5105	TO-72	25	1	0.1	15	0.5	4	15	1	5	15	15	5	10	15	100	15	5	15	0	1	15	0			50	25
2N5358	TO-72	40	1	0.1	20	0.5	3	15	100	0.5	1	15	1	3	15	10	15	6	15	0	2	15	0	115	100	55	25
2N5359	TO-72	40	1	0.1	20	0.8	4	15	100	0.6	1.6	15	1.2	3.6	15	10	15	6	15	0	2	15	0	115	100	55	25
2N5360	TO-72	40	1	0.1	20	0.8	4	15	100	1.5	3.0	15	1.4	4.2	15	20	15	6	15	0	2	15	0	115	100	55	25
2N5361	TO-72	40	1	0.1	20	1	6	15	100	2.5	5	15	1.5	4.5	15	20	15	6	15	0	2	15	0	115	100	55	25
2N5362	TO-72	40	1	0.1	20	2	7	15	100	4	8	15	2	5.5	15	40	15	6	15	0	2	15	0	115	100	55	25
2N5363	TO-72	40	1	0.1	20	2.5	8	15	100	7	14	15	2.5	6	15	40	15	6	15	0	2	15	0	115	100	55	25
2N5364	TO-72	40	1	0.1	20	2.5	8	15	100	9	18	15	2.7	6.5	15	60	15	6	15	0	2	15	0	115	100	55	25
2N5457	TO-92	25	1	1	15	0.5	6	15	10	1	5	15	2	5	15	50	15	7	15	0	3	15	0			55	92
2N5458	TO-92	25	1	1	15	1	7	15	10	2	9	15	1.5	5.5	15	50	15	7	15	0	3	15	0			55	92
2N5459	TO-92	25	1	1	15	2	8	15	10	4	16	15	2	6	15	50	15	7	15	0	3	15	0			55	92
2N5556	TO-72	30	1	0.1	15	0.2	4	15	1	0.5	2.5	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
2N5557	TO-72	30	1	0.1	15	0.8	5	15	1	2	5	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
2N5558	TO-72	30	1	0.1	15	1.5	6	15	1	4	10	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
J201	TO-92	40	1	0.1	20	0.3	1.5	20	10	0.2	1	20	0.5		20											52	92
J202	TO-92	40	1	0.1	20	0.8	4	20	10	0.9	4.5	20	1		20											52	92
J203	TO-92	40	1	0.1	20	2	10	20	10	4	20	20	1.5		20											52	92
J210	TO-92	25	1	0.1	15	1	3	15	1	2	15	15	4	12	15	150	15									90	92
J211	TO-92	25	1	0.1	15	2.5	4.5	15	1	7	20	15	7	12	15	200	15									90	92
J212	TO-92	25	1	0.1	15	4	6	15	1	15	40	15	7	12	15	200	15									90	92
MPF103	TO-92	25	1	1	15		6	15	1	1	5	15	1	5	15	50	15	7	15	0	3	15	0			55	92
MPF104	TO-92	25	1	1	15		7	15	1	2	9	15	1.5	5.5	15	50	15	7	15	0	3	15	0			55	92
MPF105	TO-92	25	1	1	15		8	15	1	4	16	15	2	6	15	50	15	7	15	0	3	15	0			55	92
MPF109	TO-92	25	10	1	15	0.2	8	15	10	0.5	24	15	0.8	6	15	75	15	7	15	0	3	15	0	115	1000	55	92
MPF110	TO-92	20	10	100	10	0.5	10	10	1	0.5	20	10	0.5		10											50	92
MPF111	TO-92	20	10	100	10	0.5	10	10	1000	0.5	20	10	0.5		10	200	10									50	92
MPF112	TO-92	25	10	100	10	0.5	10	10	1000	1	25	10	1	7.5	10											55	92
PN3684	TO-92	50	1	0.1	30	2	5	20	1	2.5	7.5	20	2	3	20	50	20	4	20	0	1.2	20	0	150	20	52	92
PN3685	TO-92	50	1	0.1	30	1	3.5	20	1	1	3	20	1.5	2.5	20	25	20	4	20	0	1.2	20	0	150	20	52	92
PN3686	TO-92	50	1	0.1	30	0.6	2	20	1	0.4	1.2	20	1	2	20	10	20	4	20	0	1.2	20	0	150	20	52	92

General Purpose Amplifiers (Continued)

N-Channel JFETs

Type No.	Case Style	BV_{GSS} $*BV_{GDO}$ (V) @ I_G		I_{GSS} (nA) @ V_{DG}		V_P (V) @ V_{DS}			I_D	I_{DSS} (mA) @ V_{DS}			G_{fs} (mmho) @ V_{DS}			G_{oss} (µmho) @ V_{DS}		C_{iss} (pF) @ V_{DS}		V_{GS}	C_{rss} (pF) @ V_{DS}		V_{GS}	$\left(\frac{NV}{\sqrt{Hz}}\right)^{e_n}$ @ Freq.		Process No.	Pkg. No.
		Min	(µA)	Max	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Min	Max	(V)	Max	(V)	Max	(V)	(V)	Max	(V)	(V)	Max	(Hz)		
PN3687	TO-92	50	1	0.1	30	0.3	1.2	20	1	0.1	0.5	20	0.5	1.5	20	5	20	4	20	0	1.2	20	0	150	20	52	92
PN4220	TO-92	30	10	0.1	15		4	15	1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0			55	92
PN4221	TO-92	30	10	0.1	15		6	15	1	2	6	15	2	5	15	20	15	6	15	0	2	15	0			55	92
PN4222	TO-92	30	10	0.1	15		8	15	1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0			55	92
PN4302	TO-92	30	1	1	10		4	20	10	0.5	5	20	1		20	50	20	6	20	0	3	20	0	100	1000	52	92
PN4303	TO-92	30	1	1	10		6	20	10	4	10	20	2		20	50	20	6	20	0	3	20	0	100	1000	52	92
PN4304	TO-92	30	1	1	10		10	20	10	0.5	15	20	1		20	50	20	6	20	0	3	20	0	125	1000	52	92
PN4338	TO-92	50	1	0.1	30	0.3	1	15	100	0.2	0.6	15	0.6	1.8	15	5	15	7	15	0	3	15	0			52	92
PN4339	TO-92	50	1	0.1	30	0.6	1.8	15	100	0.5	1.5	15	0.8	2.4	15	15	15	7	15	0	3	15	0			52	92
PN5163	TO-92	25	1	10	15	0.4	8	15	1000	1	40	15	2	9	15	200	15	12	15	0	3	15	0	50	1000	50	92
TIS58	TO-92	25	1	4	15	0.5	5	15	20	2.5	8	15	1.3	4	15			6	15	2 mA	3	15	2 mA			50	94
TIS59	TO-92	25	1	4	15	1	9	15	20	6	25	15	1.3		15			6	15	2 mA	3	15	2 mA			50	94

National Semiconductor

N-Channel JFETs

General Purpose Dual JFETs

Type No.	Case Style	Operating Conditions for these Characteristics											V_P (V)		I_{DSS} (mA)		G_{fs} (mmho)		G_{oss} (μmho)	I_{GSS} (pA @ V_{DG}		C_{iss} (pF)	C_{rss} (pF)	BV (V)	e_R (nVf $\sqrt{Hz}$) @ f		I_{DSS} Match	G_{fs} Match	G_{osc1-2} (μmho)	$I_{G1}-I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
		Op. Char. V_{DG} (V)	I_D (μA)	$\lvert V_{GS1-2}\rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} μmhos Min	Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	(V)	Max	Max	Min	Max	(Hz)	%	%				
2N3921	TO-71	10	700	5	10	250	1500		20					−3.0	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N3922	TO-71	10	700	5	25	250	1500		20					−3.0	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N3934	TO-71	10	200	5	10	100	300		5				See 2N3954-6 as an improved replacement																			12
2N3935	TO-71	10	200	5	25	100	300		5				See 2N3954-6 as an improved replacement																			12
2N3954A	TO-71	20	200	5	5	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	3		10	83	12
2N3954	TO-71	20	200	5	10	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	3		10	83	12
2N3955A	TO-71	20	200	5	15	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	3		10	83	12
2N3955	TO-71	20	200	10	25	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	5		10	83	12
2N3956	TO-71	20	200	15	50	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	5	5		10	83	12
2N3957	TO-71	20	200	20	75	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	10	10		10	83	12
2N3958	TO-71	20	200	25	100	50					0.5	4	1	4.5	0.5	5	1	3	35	100	30	4	1.2	50	150	100	15	15		10	83	12
2N4082	TO-71	10	200	15	10	100	300		10				See 2N3954-6 as an improved replacement																			12
2N4083	TO-71	10	200	15	25	100	300		10				See 2N3954-6 as an improved replacement																			12
2N4084	TO-71	10	700	15	10	250	1500		20		0.5	4		3	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N4085	TO-71	10	700	15	25	250	1500		20					3	1	10	1.5	7.5	35	1000	30	18	6	50	100	1000		5			83	12
2N5045	TO-71	15	200	5.0	67								0.5	4.5	0.5	8	1.5	6	25	250	30	8	4	50	200	10					83	12
2N5046	TO-71	15	200	10	133								0.5	4.5	0.5	8	1.5	6	25	250	30	8	4	50	200	10					83	12
2N5047	TO-71	15	200	15	200								0.5	4.5	0.5	8	1.5	6	25	250	30	8	4	50	200	10		20	3		83	12
2N5196	TO-71	20	200	5	5	15	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	3	1	5	83	12
2N5197	TO-71	20	200	5	10	15	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	3	1	5	83	12
2N5198	TO-71	20	200	10	20	15	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	3	1	5	83	12
2N5199	TO-71	20	200	15	40	17	700	1500	4		0.2	3.8	0.7	4.5	0.7	7	1	4	50	25	30	6	2	50	20	1000	5	3	1	5	83	12
2N5452	TO-71	20	200	5	5				1		0.2	4.2	1	4.5	0.5	5	1	3	3	100	30	4	1.2	50	20	1000	5	3	0.25		83	12
2N5453	TO-71	20	200	10	10				1		0.2	4.2	1	4.5	0.5	5	1	3	3	100	30	4	1.2	50	20	1000	5	3	0.25		83	12
2N5454	TO-71	20	200	15	25				1		0.2	4.2	1	4.5	0.5	5	1	3	3	100	30	4	1.2	50	20	1000	5	3	0.25		83	12
2N5545	TO-71	15	200	5	10	50							0.5	4.5	0.5	8	1.5	6	25	100	30	6	2	50	180	10	5	3	1	5	83	12
2N5546	TO-71	15	200	10	20	50							0.5	4.5	0.5	8	1.5	6	25	100	30	6	2	50	200	10	10	5	2	5	83	12
2N5547	TO-71	15	200	15	40	50							0.5	4.5	0.5	8	1.5	6	25	100	30	6	2	50			10	10	3	5	83	12
2N5561	TO-71	10	700	5	5		2000	3000	4		0.2	2.7†	0.8	3	1	10				100	30	15	4	50	50	10	5	3	0.3	10	98	12
2N5562	TO-71	10	700	10	10		2000	3000	4		0.2	2.7†	0.8	3	1	10				100	30	15	4	50	50	10	5	3	0.4	10	98	12
2N5563	TO-71	10	700	15	25		2000	3000	4		0.2	2.7†	0.8	3	1	10				100	30	15	4	50	50	10	5	3	0.5	10	98	12

†I_D = 100 μA for V_{GS} for 2N556/1/2/3 only.

General Purpose Dual JFETs (Continued)

N-Channel JFETs

Type No.	Case Style	Operating Conditions for these Characteristics: Op. Char. V_{DG} (V)	Op. Char. I_D (µA)	$\lvert V_{GS1-2} \rvert$ V_{OS} (mV) Max	Drift (µV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} µmhos Min	G_{fs} µmhos Max	G_{oss} (µmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_P (V) Min	V_P (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (µmho) Max	I_{GSS} (pA @ V_{DG} Max	I_{GSS} V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_R (nV/$\sqrt{Hz}$) Max	@ f (Hz)	I_{DSS} Match %	G_{fs} Match %	G_{osc1-2} (µmho)	$I_{G1}-I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
J401		10	200	5	10	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J402	8-Pin	10	200	10	10	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J403	Mini-	10	200	10	25	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J404	DIP	10	200	15	25	100	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J405		10	200	20	40	100	1000	1600	2	90		2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J406		10	200	40	80	100	1000	1600	2			2.3	0.5	2.5	0.5	10	2	7	20	100	30	8	3	50	20	10					98	60
J410	8-Pin	20	200	10	10	250	800	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100					83	60
J411	Mini	20	200	25	25	250	800	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100					83	60
J412	DIP	20	200	40	80	250	800	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100					83	60
NPD8301	8-Pin	20	200	5	t5	100	700	1200	5	70	0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
NPD8302	Mini	20	200	10	t10	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
NPD8303	DIP	20	200	15	t15	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
NPD8304	8-Pin Mini-DIP	20	200	20	t20	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100					83	67
U231	TO-71	20	200	5	10	50	600		10		0.3	4	See 2N3954 as an improved replacement																		83	12
U232	TO-71	20	200	10	25	50	600		10		0.3	4	See 2N3955 as an improved replacement																		83	12
U233	TO-71	20	200	15	50	50	600		10		0.3	4	See 2N3956 as an improved replacement																		83	12
U234	TO-71	20	200	20	75	50	600		10		0.3	4	See 2N3957 as an improved replacement																		83	12
U235	TO-71	20	200	25	100	50	600		10		0.3	4	See 2N3958 as an improved replacement																		83	12
U401	TO-71	10	200	5	10	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U402	TO-71	10	200	10	10	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U403	TO-71	10	200	10	25	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U404	TO-71	10	200	15	25	15	1000	1600	2	95		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U405	TO-71	10	200	20	40	15	1000	1600	2	90		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12
U406	TO-71	10	200	40	80	15	1000	1600	2			2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12

National Semiconductor

N-Channel JFETs

Low Frequency—Low Noise Dual JFETs

Type No.	Case Style	Operating Conditions for these Characteristics											V_P (V)		I_{DSS} (mA)		G_{fs} (mmho)		G_{oss} (μmho)	I_{GSS}		C_{iss} (pF)	C_{rss} (pF)	BV (V)	e_R		I_{DSS} Match	G_{fs} Match	G_{osc1-2} (μmho)	$I_{G1}-I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
		Op. Char. V_{DG} (V)	Op. Char. I_D (μA)	$\lvert V_{GS1-2}\rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} μmhos Min	G_{fs} μmhos Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	Min	Max	Min	Max	Min	Max	Max	(pA @ V_{DG}) Max	(V)	Max	Max	Min	(nVf $\sqrt{Hz}$ @ f) Max	(Hz)	%	%				
2N5515	TO-71	20	200	5	5	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	3	0.1	10	95	12
2N5516	TO-71	20	200	5	10	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	3	0.1	10	95	12
2N5517	TO-71	20	200	10	20	100	500	1000	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	5	0.1	10	95	12
2N5518	TO-71	20	200	15	40	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	5	0.1	10	95	12
2N5519	TO-71	20	200	15	80	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	10	10	0.1	10	95	12
2N5520	TO-71	20	200	5	5	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	3	0.1	10	95	12
2N5521	TO-71	20	200	5	10	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	3	0.1	10	95	12
2N5522	TO-71	20	200	10	20	100	500	1000	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	5	0.1	10	95	12
2N5523	TO-71	20	200	15	40	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	5	0.1	10	95	12
2N5524	TO-71	20	200	15	80	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	10	10	0.1	10	95	12
2N6483	TO-71	20	200	5	5	100	500	1500	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12
2N6484	TO-71	20	200	10	10	100	500	1500	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12
2N6485	TO-71	20	200	15	25	100	500	1500	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12

National Semiconductor

N-Channel JFETs

Wide Band—Low Noise Dual JFETs

Type No.	Case Style	Operating Conditions for these Characteristics											V_P (V)		I_{DSS} (mA)		G_{fs} (mmho)		G_{oss} (μmho)	I_{GSS} (pA @ V_{DG})		C_{iss} (pF)	C_{rss} (pF)	BV (V)	e_R (nV/$\sqrt{Hz}$) @ f		I_{DSS} Match	G_{fs} Match	G_{osc1-2} (μmho)	$I_{G1}-I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
		Op. Char. V_{DG} (V)	Op. Char. I_D (μA)	$\|V_{GS1-2}\|$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} μmhos Min	G_{fs} μmhos Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	Min	Max	Min	Max	Min	Max	Max	Max	(V)	Max	Max	Min	Max	(Hz)	%	%				
2N5584	TO-71	15	2000	5	10		7500	12,500	45				0.5	3	5	30				100	20	12	3	40	50	10	5	5			98	12
2N5585	TO-71	15	2000	10	25		7500	12,500	45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			98	12
2N5586	TO-71	15	2000	20	50		7500	12,500	45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			98	12
2N5911	TO-78	10	5000	10	20	100	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	83	24
2N5912	TO-78	10	5000	15	40	100	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	83	24
U440	TO-71	10	5000	10		500	4500	9000	200				1	8.0	6	30				500	15	3.5	0.5	25							83	12
U441	TO-71	10	5000	20		500	4500	9000	200				1	8.0	6	30				500	15	3.5	0.5	25							83	12
NPD5584	8-Pin	15	2000	5			7500	12,500	45				0.5	3	5	30				100	20	12	3	40	50	10	5	5			98	67
NPD5585	Mini-	15	2000	10			7500	12,500	45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			98	67
NPD5586	DIP	15	2000	20			7500	12,500	45				0.5	3	5	30				100	20	12	3	40	50	10	5	10			98	67
NF5011	TO-71	10	5000	10	20	500	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	83	12
NF5012	TO-71	10	5000	15	40	500	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	83	12
NF5011C	TO-71	10	5000	40	40	500	5000	10,000	100		0.3	4	1	5	7	40				100	15	5	1.2	25	20	10,000	5	5	20	20	83	12
U287	TO-78	10	5000	100			5000	10,000	150				1	5	5	40				100	15	5	1.2	25	30	10,000	15	15	20		83	24

National Semiconductor

N-Channel JFETs

Low Leakage—High CMRR—Wide Band Dual JFETs

		Operating Conditions for these Characteristics																															
Type No.	Case Style	Op. Char. V_{DG} (V)	Op. Char. I_D (μA)	$\lvert V_{GS1-2} \rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G(pF) @ V_{DG} 35V	G_{fs} μmhos Min	G_{fs} μmhos Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	V_{gs} (V) Max	V_P (V) Min	V_P (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (μmho) Max	I_{GSS} (pA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV (V) Min	e_R (nVf $\sqrt{Hz}$) Max	@ f (Hz)	I_{DSS} Match %	G_{fs} Match %	G_{osc1-2} (μmho)	$I_{G1}-I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
NDF9406	TO-71	20	200	5	5	5	700	1800	1	120			0.5	4	0.5	10				50	20	8.0	0.1	50	30	10	5	3	0.1	1	94	12
NDF9407	TO-71	20	200	5	10	5	700	1800	1	120			0.5	4	0.5	10				50	20	8.0	0.1	50	30	10	5	3	0.1	1	94	12
NDF9408	TO-71	20	200	10	10	5	700	1800	1	110			0.5	4	0.5	10				50	20	8.0	0.1	50	30	10	5	5	0.1	1	94	12
NDF9409	TO-71	20	200	15	10	5	700	1800	1	110			0.5	4	0.5	10				50	20	8.0	0.1	50	30	10	5	5	0.1	1	94	12
NDF9410	TO-71	20	200	25	25	5	700	1800	1	100			0.5	4	0.5	10				50	20	8.0	0.1	50	30	10	10	10	0.1	1	94	12

National Semiconductor

N-Channel JFETs

Ultra Low Leakage Dual JFETs

Type No.	Case Style	Operating Conditions for these Characteristics: Op. Cond. V_{DG} (V)	Op. Cond. I_D (µA)	V_{GS1-2} V_{OS} (mV) Max	ΔV_{GS} Drift (µV/°C) Max	I_G (pA) Max	G_{fs} (mmho) Min	G_{oss} (µmho) Max	V_{gs} (V) Max	V_P (V) Min	V_P (V) Max	I_{DSS} (mA) Min	I_{DSS} (mA) Max	G_{fs} (mmho) Min	G_{fs} (mmho) Max	G_{oss} (µmho) Max	I_{GSS} (pA @ V_{GS}) Max	I_{GSS} V_{GS} (V)	C_{iss} (pF) Max	C_{rss} (pF) Max	BV_{GSS} (V) Min	$I_{G1}-I_{G2}$ @125°C (nA) Max	Process No.	Pkg. No.
2N5902	TO-78	10	30	5	5	3	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	5	20	3	1.5	40	2	84	24
2N5903	TO-78	10	30	5	10	3	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	5	20	3	1.5	40	2	84	24
2N5904	TO-78	10	30	10	20	3	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	5	20	3	1.5	40	2	84	24
2N5905	TO-78	10	30	15	40	3	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	4	5	20	3	1.5	40	2	84	24
2N5906	TO-78	10	30	5	5	1	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	2	20	3	1.5	40	0.2	84	24
2N5907	TO-78	10	30	5	10	1	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	2	20	3	1.5	40	0.2	84	24
2N5908	TO-78	10	30	10	20	1	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	2	20	3	1.5	40	0.2	84	24
2N5909	TO-78	10	30	15	40	1	50µ	1	4	0.6	4.5	30µ	0.5	70µ	0.25	5	2	20	3	1.5	40	0.2	84	24

National Semiconductor

P-Channel JFETs

Switches

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) Min	@ I_G (μA)	I_{GSS} (nA) Max	@ V_{DG} (V)	$I_{D(off)}$ (nA) Max	@ V_{DS} (V)	V_{GS} (V)	V_P (V) Min	V_P (V) Max	@ V_{DS} (V)	I_D (nA)	I_{DSS} (mA) Min	I_{DSS} (mA) Max	@ V_{DS} (V)	r_{ds} (Ω) Max	@ I_D (mA)	C_{iss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	V_{GS} (V)	t_{on} (ns) Max	t_{off} (ns) Max	Process No.	Pkg. No.
2N5018	TO-18	30	1	2	15	10	−15	12		10	−15	1	10		20	75		45	−15	0	10	0	12	35	65	88	11
2N5019	TO-18	30	1	2	15	10	−15	7		5	−15	1	5		20	150		45	−15	0	10	0	7	90	125	88	11
2N5114	TO-18	30	1	0.5	20	0.5	−15	12	5	10	−15	0.001	30	90	18	75	1	25	−15	0	7	0	12	16	21	88	11
2N5115	TO-18	30	1	0.5	20	0.5	−15	7	3	6	−15	0.001	16	90	18	100	1	25	−15	0	7	0	7	30	38	88	11
2N5116	TO-18	30	1	0.5	20	0.5	−15	5	1	4	−15	0.001	5	90	18	150	1	25	−15	0	7	0	5	42	60	88	11
J174	TO-92	30	1	1	20	1	−15	10	5	10	−15	0.01	20	100	15	85	1	11	0	10	5.5	0	10	2	5	88	94
J175	TO-92	30	1	1	20	1	−15	10	3	6	−15	0.01	7	60	15	125	0.5	11	0	10	5.5	0	10	5	10	88	94
J176	TO-92	30	1	1	20	1	−15	10	1	4	−15	0.01	2	25	15	250	0.25	11	0	10	5.5	0	10	15	15	88	94
J177	TO-92	30	1	1	20	1	−15	10	0.8	2.25	−15	0.01	1.5	20	15	300	0.1	11	0	10	5.5	0	10	20	20	88	94
P1086	TO-92	30	1	2	15	10	−15	12		10	−15	1	10		20	75	1	45	−15	0	10	0	12	35	65	88	92
P1087	TO-92	30	1	2	15	10	−15	7		5	−15	1	5		20	150	1	45	−15	0	10	0	7	90	125	88	92

National Semiconductor

P-Channel JFETs

Amplifiers

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) @ I_G Min	(μA)	I_{GSS} (nA) @ V_{DG} Max	(V)	V_P (V) @ V_{DS} Min	Max	(V)	I_D (μA)	I_{DSS} (mA) @ V_{DS} Min	Max	(V)	G_{fs} (mmho) @ V_{DS} Min	Max	(V)	G_{oss} (μmho) V_{DS} Max	(V)	C_{iss} (pF) V_{DS} Max	(V)	V_{GS} (V)	C_{rss} (pF) V_{DS} Max	(V)	V_{GS} (V)	e_n $\left(\frac{NV}{\sqrt{Hz}}\right)$ @ Freq Max	(Hz)	Process No.	Pkg. No.
2N2608	TO-18	30	1	10	30	1	4	−5	1	0.9	4.5	5	1		5			17	−5	1				125	1000	89	11
2N2609	TO-18	30	1	30	30	1	4	−5	1	2	10	5	2.5		5			30	−5	1				125	1000	88	11
2N3329	TO-72	20	10	10	10		5	−15	10	1	3	10	1	2	10/1 mA	20	10	20	−10	1				125	1000	89	23
2N3330	TO-72	20	10	10	10		6	−15	10	2	6	10	1.5	3	10/2 mA	40	10	20	−10	1				125	1000	89	23
2N3331	TO-72	20	10	10	10		8	−15	10	5	15	10	2	4	10/5 mA	100	10	20	−10	1				155	1000	89	23
2N3332	TO-72	20	10	10	10		6	−15	10	1	6	10	1	2.2	10/1 mA	20	10	20	−10	1				65	1000	89	23
2N3820	TO-92	20	10	20	10		8.0	−10	10	0.3	15	10	0.8	5	10	200	10	32	−10	0	16	−10	0			89	94
2N4381	TO-18	25	1	1	15	1	5	−15	1	3	12	15	2	6	15	75	15	20	−15	0	5	−15	0	20	1000	89	11
2N5020	TO-18	25	1	1	15	0.3	1.5	−15	1	0.3	1.2	15	1	3.5	15	20	15	25	−15	0	7	−15	0	30	1000	89	11
2N5021	TO-18	25	1	1	15	0.5	2.5	−15	1	1	3.5	15	1.5	6	15	20	15	25	−15	0	7	−15	0	30	1000	89	11
2N5460	TO-92	40	10	5	20	0.75	6	−15	1	1	5	15	1	4	15	50	15	7	−15	0	2	−15	0	115	100	89	92
2N5461	TO-92	40	10	5	20	1	7.5	−15	1	2	9	15	1.5	5	15	50	15	7	−15	0	2	−15	0	115	100	89	92
2N5462	TO-92	40	10	5	20	1.8	9	−15	1	4	16	15	2	6	15	50	15	7	−15	0	2	−15	0	115	100	89	92
J270	TO-92	30	1	0.2	20	0.5	2.0	−15	0.001	2	15	15	6.0	15	15	200	15	t20	−15	0	t5	−15	0	t10	1000	88	94
J271	TO-92	30	1	0.2	20	1.5	4.5	−15	0.001	6	50	15	8.0	18		500	15	t20	−15	0	t5	−15	0	t10	1000	88	94
PN4342	TO-92	25	10	10	15		5.5	−10	1	4	12	10	2	6	10	75	10	20	−10	0	5	−10	0	80	100	89	92
PN4360	TO-92	20	10	10	15	0.7	10	−10	1	3	30	10	2	8	10	100	10	20	−10	0	5	−10	0	190	100	89	92
PN5033	TO-92	20	10	10	15	0.3	2.5	−10	1	0.3	3.5	10	1	5	10	20	10	25	−10	0	7	−10	0	100	100	89	92

t = typical value.

Section 6
Surface Mount Products

Section 6 Contents

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National Semiconductor

Surface Mount Diodes

General Purpose & Specialty Diodes

PLASTIC PACKAGE

Device	Description	Pkg. No.	Pin Out	B_V (V) Min	I_R (nA) Max @	V_R V	V_F (V) Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDSO 1000 FAMILY												D4
BAS16	Single	TO-236	(1)	75	1000	75	0.715 0.855	1.0 10.0	2.0	6.0	(Note 1)	D4
BAV70	Common Cathode	TO-236	(4)	70	5000	70	1.1 1.3	50.0 100.0	1.5	6.0	(Note 2)	D4
BAV74	Common Cathode	TO-236	(4)	50	100	50	1.0	100	2.0	4.0	(Note 3)	D4
BAV99	Series	TO-236	(3)	70	2500	70	See BAS 16		1.5	6.0	(Note 4)	D4
BAW56	Common Anode	TO-236	(5)	70	2500	70	See BAS 16		2.5	6.0	(Note 4)	D4
FDSO 914	Single	TO-236	(1)	100	25	20	1.0	10	4.0	4.0	(Note 5)	D4
FDSO 4148	Single	TO-236	(1)	100	25	20	1.0	10	4.0	4.0	(Note 5)	D4
FDSO 4448	Single	TO-236	(1)	100	25	20	1.0	100	2.0	4.0	(Note 5)	D4
FSDO 1200 FAMILY												
FDSO 1201	Single	TO-236	(1)	100	25	20	1.0	100	2.0	4.0		D4
FDSO 1202	Single	TO-236	(2)	100	25	20	1.0	100	2.0	4.0		D4
FDSO 1203	Series	TO-236	(3)	100	25	20	1.0	100	2.0	4.0		D4
FDSO 1204	Common Cathode	TO-236	(4)	100	25	20	1.0	100	2.0	4.0		D4
FDSO 1205	Common Anode	TO-236	(5)	100	25	20	1.0	100	2.0	4.0		D4

TEST CONDITIONS:

Note 1: $I_F = I_R = 10$ mA, $R_L = 100\Omega$.

Note 2: $I_F = I_R = 10$ mA, $V_R = 5.0$V, $I_{R\,(REC)} = 1.0$ mA.

Note 3: $I_F = I_R = 10\ \mu$A, $R_L = 100\Omega$, $I_{R\,(REC)} = 1.0\ \mu$A measured at $I_R = 1.0$ mA.

Note 4: $I_F = I_R = 10$ mA, $I_{V\,(REC)} = 1.0$ mA.

Note 5: $I_F = 10$ mA, $V_R = 6$V, $R_L = 100\Omega$ Rec @ 1.0 mA.

Surface Mount Diodes

General Purpose & Specialty Diodes (Continued)

PLASTIC PACKAGE

Device	Description	Pkg. No.	Pin Out	B_V (V) Min	I_R (nA) Max @	V_R V	V_F (V) Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDSO 1300 FAMILY												D6
FDSO 1301	Single	TO-236	(1)	30	Consult Factory		1.1	50				D6
FDSO 1400 FAMILY												D1
FDSO 1401	Single	TO-236	(1)	200	100	175	1.0	200	2.0	50		D1
FDSO 1402	Single	TO-236	(2)	200	100	175	1.0	200	2.0	50		D1
FDSO 1403	Series	TO-236	(3)	200	100	175	1.0	200	2.0	50		D1
FDSO 1404	Common Cathode	TO-236	(4)	200	100	175	1.0	200	2.0	50		D1
FDSO 1405	Common Anode	TO-236	(5)	200	100	175	1.0	200	2.0	50		D1
FDSO 3070	Single	TO-236		200	100	175	1.0	100	5.0	50	(Note 2)	D2
FDSO 1500 FAMILY												D2
FDSO 1501	Single	TO-236	(1)	200	1.0	125	1.0	200	4.0			D2
FDSO 1502	Single	TO-236	(2)	200	1.0	125	1.0	200	4.0			D2
FDSO 1503	Series	TO-236	(3)	200	1.0	125	1.0	200	4.0			D2
FDSO 1504	Common Cathode	TO-236	(4)	200	1.0	125	1.0	200	4.0			D2
FDSO 1505	Common Anode	TO-236	(5)	200	1.0	125	1.0	200	4.0			D2
FDSO 3595	Single	TO-236		150	1.0	125	1.0 See 1N6099	200	8.0			D2

TEST CONDITIONS:

Note 1: $I_F = I_R = 30$ mA, $R_L = 100\Omega$

Note 2: $I_F = I_R = 30$ mA, $R_L = 100\Omega$

Surface Mount Diodes

General Purpose Diodes & Specialty Diodes (Continued)

PLASTIC PACKAGE

Device	Description	Pkg. No.	Pin Out	B_V (V) Min	I_R (nA) Max @	V_R V	V_F (V) Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDSO 1700 FAMILY												D3
FDSO 1701	Single	TO-236	(1)	30	50	20	1.1	50	1.0	0.7		D3
FDSO 1702	Single	TO-236	(2)	30	50	20	1.1	50	1.0	0.7		D3
FDSO 1703	Series	TO-236	(3)	30	50	20	1.1	50	1.0	0.7		D3
FDSO 1704	Common Cathode	TO-236	(4)	30	50	20	1.1	50	1.0	0.7		D3
FDSO 1705	Common Anode	TO-236	(5)	30	50	20	1.1	50	1.0	0.7		D3

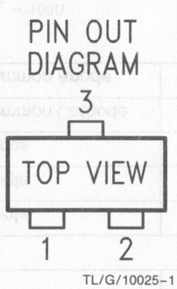
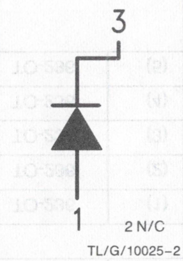
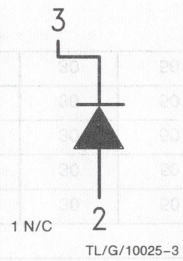
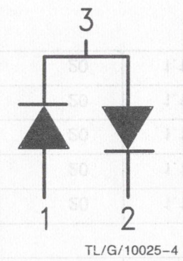
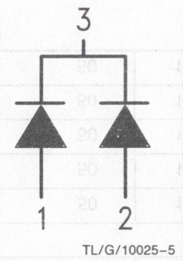
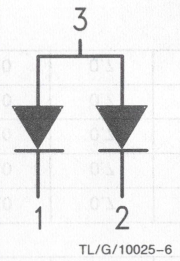
TEST CONDITIONS:

Note 1: $I_F = I_R = 10$ mA, $R_L = 100\Omega$

General Purpose Diodes & Specialty Diodes (Continued)

The National "FDSO" Series provides the SOT-23 electrical equivalent of the standard devices listed. Each family is available in 5 configurations.

FDSO1200 FAMILY			FDSO1400 FAMILY		FDSO1500 FAMILY		FDSO1700 FAMILY
1N914	1N4149	FDH600	1N625	1S922	1N456	1N463A	1N4244
1N914A	1N4150	FDH666	1N626	1S923	1N456A	1N482B	1N4376
1N914B	1N4151		1N627	FDH400	1N457	1N483B	FDH700
1N916	1N4154		1N628	FDH444	1N457A	1N484B	
1N916A	1N4305		1N629		1N458	1N485B	
1N916B	1N4446		1N658		1N458A	1N3595	
1N3064	1N4448		1N660		1N459	1N6099	
1N3600	1N4449		1N3070		1N459A	FDH300	
1N4009	1N4450		1S920		1N461A	FDH333	
1N4148	1N4455		1S921		1N462A		

Configuration	1	2	3	4	5
 PIN OUT DIAGRAM 3 TOP VIEW 1 2 TL/G/10025-1	 3 1 2 N/C TL/G/10025-2	 3 1 N/C 2 TL/G/10025-3	 3 1 2 TL/G/10025-4	 3 1 2 TL/G/10025-5	 3 1 2 TL/G/10025-6

National Semiconductor

Surface Mount Diodes

Computer Diodes

LEADLESS GLASS PACKAGE

Device No.	Package No.	B_V (V) Min	I_R (nA) Max @	V_R V	V_F (V) Max @	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDLL 600	LL-34	75	100	50	1.0	200	2.5	4.0	(Note 1)	D4
					See FDH 600					
FDLL 625	LL-34	30	1000	20	1.5	4.0		50		D4
FDLL 666	LL-34	40	100	25	1.0	100	3.5	4.0	(Note 1)	D4
					See FDH 666					
FDLL 914	LL-34	100	25	20	1.0	10	4.0	4.0	(Note 2)	D4
FDLL 914A	LL-34	100	25	20	1.0	20	4.0	4.0	(Note 2)	D4
FDLL 914B	LL-34	100	25	20	1.0	100	4.0	4.0	(Note 2)	D4
FDLL 916	LL-34	100	25	20	1.0	10	2.0	4.0	(Note 2)	D4
FDLL 916A	LL-34	100	25	20	1.0	20	2.0	4.0	(Note 2)	D4
FDLL 916B	LL-34	100	25	20	1.0	30	2.0	4.0	(Note 2)	D4
FDLL 3064	LL-34	75	100	50	1.0	10	2.0	4.0	(Note 3)	D4
					See IN3064					
FDLL 3600	LL-34	75	100	50	1.0	200	2.5	4.0	(Note 4)	D4
					See IN3600					
FDLL 4009	LL-34	35	100	25	1.0	30	4.0	4.0	(Note 2)	D4
FDLL 4148	LL-34	100	25	20	1.0	10	4.0	4.0	(Note 2)	D4
FDLL 4149	LL-34	100	25	20	1.0	10	2.0	4.0	(Note 2)	D4
FDLL 4150	LL-34	75	100	50	1.0	200	2.5	4.0	(Note 4)	D4

TEST CONDITIONS:

Note 1: Recovery to 0.1 I_R; $I_F = I_R = 10$ mA, $R_L = 100\Omega$

Note 2: $I_F = 10$ mA, $V_R = 6.0$V, $R_L = 100\Omega$, Recovery to 1.0 mA

Note 3: $I_F = I_R = 10$ mA, $R_L = 100\Omega$, Recovery to 1.0 mA

Note 4: $I_F = I_R = 10$ mA to 200 mA, $R_L = 100\Omega$, Recovery to 0.1 I_F

Surface Mount Diodes

Computer Diodes (Continued)

LEADLESS GLASS PACKAGE

Device No.	Package No.	B_V (V) Min	I_R (nA) Max	@	V_R V	V_F (V) Max	@	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDLL 4151	LL-34	75	50		50	1.0		50	4.0	2.0	(Note 2)	D4
FDLL 4152	LL-34	40	50		30	0.88		20	4.0	2.0	(Note 2)	D4
						See IN4152						
FDLL 4153	LL-34	75	50		50	0.88		20	4.0	2.0	(Note 2)	D4
FDLL 4154	LL-34	35	100		25	1.0		30	4.0	2.0	(Note 2)	D4
						See IN4152						
FDLL 4305	LL-34	75	100		50	0.85		10	2.0	2.0	(Note 2)	D4

TEST CONDITIONS:

Note 1: Recovery to 0.1 I_R; $I_F = I_R = 10$ mA, $R_L = 100\Omega$

Note 2: $I_F = 10$ mA, $V_R = 6.0V$, $R_L = 100\Omega$, Recovery to 1.0 mA

Note 3: $I_F = I_R = 10$ mA, $R_L = 100\Omega$, Recovery to 1.0 mA

Note 4: $I_F = I_R = 10$ mA to 200 mA, $R_L = 100\Omega$, Recovery to 0.1 I_F

LEADLESS GLASS PACKAGE

Device No.	Package No.	B_V (V) Min	I_R (nA) Max	@	V_R V	V_F (V) Max	@	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDLL 4446	LL-34	100	25		20	1.0		20	4.0	4.0	(Note 1)	D4
FDLL 4447	LL-34	100	25		20	1.0		20	4.0	4.0	(Note 1)	D4
FDLL 4448	LL-34	100	25		20	1.0		100	2.0	4.0	(Note 1)	D4
FDLL 4449	LL-34	100	25		20	1.0		30	2.0	4.0	(Note 1)	D4
FDLL 4450	LL-34	40	50		30	1.0		200	4.0	4.0	(Note 2)	D4
						See IN4450						
FDLL 4454	LL-34	75	100		50	1.0		10	2.0	4.0	(Note 3)	D4

TEST CONDITIONS:

Note 1: $I_F = 10$ mA, $V_R = 6.0V$, $R_L = 100\Omega$, Recovery to 1 mA

Note 2: $I_F = I_R = 10$ mA to 200 mA, $R_L = 100\Omega$, Recovery to 0.1 I_F

Note 3: $I_F = I_R = 10$ mA, $R_L = 100\Omega$, Recovery to 1.0 mA

National Semiconductor

Surface Mount Diodes

General Purpose Diodes

LEADLESS GLASS PACKAGE

Device No.	Package No.	B_V (V) Min	I_R (nA) Max	@	V_R V	V_F (V) Max	@	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDLL 461A	LL-34	30	500		25	1.0		100	10.0			D2
FDLL 462A	LL-34	70	500		60	1.0		100				D2
FDLL 463A	LL-34	200	500		175	1.0		6				D2
FDLL 659	LL-34	60	5000		50	1.0		6				D2
FDLL 661	LL-34	240	10,000		200	1.0		6				D2
FDLL 920	LL-34	50	100		50	1.2		200				D2
FDLL 921	LL-34	100	100		100	1.2		200				D1
FDLL 922	LL-34	150	100		150	1.2		200				D1
FDLL 923	LL-34	200	100		200	1.0		6				D1

National Semiconductor

Surface Mount Diodes

Low Leakage Diodes (by Descending B_V)

LEADLESS GLASS PACKAGE

Device No.	Package No.	B_V (V) Min	I_R (nA) Max	@	V_R V	V_F (V) Max	@	I_F mA	C pF Max	Proc. Family
FDLL300	LL-34	150	1.0	 See IN300	125	1.0		200	6.0	D2
FDLL333	LL-34	150	3.0	 See IN333	125	1.05		200	6.0	D2
FDLL456	LL-34	30	25		25	1.0		40	10.0	D2
FDLL456A	LL-34	30	25		25	1.0		100		D2
FDLL457	LL-34	70	25		60	1.0		20	8.0	D2
FDLL457A	LL-34	70	25		60	1.0		100		D2
FDLL458	LL-34	150	25		125	1.0		7	6.0	D2
FDLL458A	LL-34	150	5.0		125	1.0		100		D2
FDLL459	LL-34	200	25		175	1.0		3.0		D2
FDLL459A	LL-34	200	25		175	1.0		100		D2
FDLL482B	LL-34	40	25		36	1.0		100		D2
FDLL483B	LL-34	80	25		70	1.0		100		D2
FDLL484B	LL-34	150	25		130	1.0		100		D2
FDLL485B	LL-34	200	25		180	1.0		100		D2
FDLL3595	LL-34	150	1.0		125	1.0		200	8.0	D2
FDLL6099	LL-34	150	1.0		125	1.0		200	8.0	D2

National Semiconductor

Surface Mount Diodes

High Voltage Diodes

LEADLESS GLASS PACKAGE

Device No.	Package No.	B_V (V) Min	I_R (nA) Max	@	V_R V	V_F (V) Max	@	I_F mA	C pF Max	t_{rr} ns Max	Test Cond.	Proc. Family
FDLL 400	LL-34	200	100		150	1.0		200	2.0	50	(Note 1)	D1
FDLL 626	LL-34	50	1000		35	1.5		4		1000	(Note 2)	D1
FDLL 627	LL-34	100	1000		75	1.5		4		1000	(Note 2)	D1
FDLL 628	LL-34	150	1000		125	1.5		4		1000	(Note 2)	D1
FDLL 629	LL-34	200	1000		175	1.5		4		1000	(Note 2)	D1
FDLL 658	LL-34	120	50		50	1.0		100		300	(Note 3)	D1
FDLL 660	LL-34	120	5000		100	1.0		6		300	(Note 4)	D1
FDLL 3070	LL-34	200	100		175	1.0		100	5.0	50	(Note 5)	D1

TEST CONDITIONS:

Note 1: $I_F = 30$ mA, $I_R = 30$ mA, $R_L = 100\Omega$

Note 2: $I_F = 30$ mA, $V_R = 35V$, Recovery to 400 kΩ

Note 3: $V_R = 40V$, $I_F = 5.0$ mA, $R_L = 2.0$ kΩ, $C_L = 10$ pF, Recovery to 80 kΩ

Note 4: $V_R = 35V$, $I_F = 30$ mA, $R_L = 2.0$ kΩ, $C_L = 10$ pF, Recovery to 400 kΩ

Note 5: $I_F = I_R = 30$ mA, $R_L = 100\Omega$

National Semiconductor

Surface Mount Diodes

Surface Mount Monolithic Diode Arrays

PLASTIC PACKAGES

Device No.	Config.	Pkg. No.	B_V V Min	V_F (V) Max @	I_F mA	ΔV_F mV Max	t_{rr} ns Max	Test Cond.	Proc. Family
FASO2501	M16	14-SOIC	60	1.1 1.2 1.5	200 300 500	15	10	(Note 1)	D15
FASO2503	2M8	14-SOIC	60	1.0 1.1 1.5	100 200 500	15	10	(Note 1)	D15
FASO2509	2M8	14-SOIC	60	1.0	100	15	10	(Note 1)	D15
FASO2510	M16	14-SOIC	60	1.1 1.3	200 500	15	10	(Note 1)	D15
FASO2563	CC8	14-SOIC	60	1.0	100	15	10	(Note 1)	D15
FASO2564	CA8	14-SOIC	60	1.1 1.3	200 500	15	10	(Note 1)	D15
FASO2565	CC13	16-SOIC	60	See FASO2563/64		15	10	(Note 1)	D15
FASO2566	CA13	16-SOIC	60	See FASO2563/64		15	10	(Note 1)	D15
FASO2619	S8	16-SOIC	100	1.0	10	15	5.0	(Note 2)	D15
FASO2620	S7	14-SOIC	100	1.0	10	15	5.0	(Note 2)	D15
FASO2719	S8	16-SOIC	75	1.0	10	15	6.0	(Note 2)	D15
FASO2720	S7	14-SOIC	75	1.0	10	15	6.0	(Note 2)	D15

TEST CONDITIONS:

Note 1: $I_F = I_R = 10$ mA to 200 mA, $R_L = 100\Omega$, $I_{RR} = 0.1\ I_R$

Note 2: $I_F = I_R = 10$ mA, $I_{RR} = 1.0$ mA

Note 3: $I_F = 200$ mA, $I_R = 200$ mA, $R_L = 100\Omega$, $I_{RR} = 20$ mA

Note 4: $I_F = I_R = 10$ mA, $I_{RR} = 1.0$ mA, $R_L = 100\Omega$

Surface Mount Transistors

Saturated Switches—NPN

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
MMBT 706	TO-236 (49)	25	15	5	500	15	20		10	1	0.6	0.7	0.9	10	6	200		10	75	(Note 2)	21
MMBT 706A	TO-236 (49)	25	15	5	500	15	20	60	10	1	0.6	0.7	0.9	10	6	200		10	75	(Note 2)	21
MMBT 2369	TO-236 (49)	40	15	4.5	400*	20	20		100	2	0.25	0.7	0.85	10	4	500		10	18	(Note 1)	21
							40	120	10	1											
MMBT 2369A	TO-236 (49)	40	15	4.5	400*	20	40	120	100	0.35	0.2	0.7	0.85	10	4	500		10	18	(Note 1)	21
							30		30	0.4	0.25			30							
							20		100	1	0.5			100							
MMBT 4274	TO-236 (49)	30*	12	4.5	500	20	18		100	1	0.2	0.7	0.85	10	4	400		10	12	(Note 12)	21
							30		30	0.4	0.25		1.15	30							
							35	120	10	1	0.5		1.6	100							
MMBT 4275	TO-236 (49)	40*	15	4.5	500	20	18		100	1	0.2	0.72	0.85	10	4	400		10	12	(Note 12)	21
							30		30	0.4	0.25		1.15	30							
							35	120	10	1	0.5		1.6	100							
MMBT 5134	TO-236 (49)	20*	10	3.5	100	15	15		30	0.4	0.25	0.7	0.9	10	4	250		10	18	(Note 12)	21
							20	150	10	1											
MMBT 5224	TO-236 (49)	25	12	5	500	15	40	400	10	1	0.35		0.9	10	4	250		10	60	(Note 11)	21
							15		100	1											
MMBT 5769	TO-236 (49)	40	15	4.5	400	20	20		100	1	0.2	0.7	0.85	10	4	500		10	18	(Note 1)	21
							30		30	0.4	0.25		1.5	30							
							40	120	10	0.35	0.5		1.6	100							

Surface Mount Transistors

Saturated Switches—NPN (Continued)

Type No.	Case Style	$V_{CES}{}^*$ V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	$I_{CES}{}^*$ I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) $(I_B = \frac{I_C}{10})$	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
MMBT 2710	TO-236 (49)	40	20	5	30	20	40		10	1	0.25		0.9	10	4	500		10	35	(Note 2)	22
							40		50	1	0.4		1.3	50							
MMBT 3013	TO-236 (49)	40	40	5	300	20	30	120	30	0.4	0.18	0.75	0.95	30	5	350		30	25	(Note 3)	22
							25		100	0.5	0.28		1.2	100							
							15		300	1	0.5		1.7	300							
MMBT 3014	TO-236 (49)	40	40	5	300	20	30	120	30	0.4	0.18	0.7	0.8	10	5	350		30	25	(Note 3)	22
							25		10	0.4	0.18	0.75	0.96	30							
							25		100	1	0.35		1.2	100							
MMBT 3646	TO-236 (49)	40	15	5	500*	20	30	120	30	0.4	0.2	0.75	0.95	30	5	350		30	28	(Note 3)	22
							20		100	0.5	0.28		1.2	100							
							15		300	1	0.5		1.7	300							
MMBT 5772	TO-236 (49)	40	15	5	500*	20	30	120	30	0.4	0.2	0.75	0.95	30	5	350		30	28	(Note 3)	22
							25		100	0.5	0.28			100							
							15		300	1	0.5			300							

TEST CONDITIONS:

Note 1: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = 3$ mA, $I_R{}^2 = 1.5$ mA

Note 2: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = 3$ mA, $I_B{}^2 = 1$ mA

Note 3: $V_{CC} = 10V$, $I_C = 300$ mA, $I_B{}^1 = I_B{}^2 = 30$ mA

Note 4: $V_{CC} = 2V$, $I_C = 30$ mA, $I_B{}^1 = I_B{}^2 = 3$ mA

Note 5: $V_{CC} = 25V$, $I_C = 300$ mA, $I_B{}^1 = I_B{}^2 = 30$ mA

Note 6: $V_{CC} = 25V$, $I_C = 500$ mA, $I_B{}^1 = I_B{}^2 = 50$ mA

Note 7: $V_{CC} = 30V$, $I_C = 500$ mA, $I_B{}^1 = I_B{}^2 = 50$ mA

Note 8: $V_{CC} = 30V$, $I_C = 1$ mA, $I_B{}^1 = I_B{}^2 = 100$ mA

Note 9: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = I_B{}^2 = 1$ mA

Note 10: $V_{CC} = 10V$, $I_C = 1A$, $I_B{}^1 = I_B{}^2 = 100$ mA

Note 11: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = I_B{}^2 = 3$ mA

Note 12: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = I_B{}^2 = 3.3$ mA

National Semiconductor

Surface Mount Transistors

RF Amplifiers and Oscillators—NPN

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Min	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	$t_{(off)}$ (ns) Max	Test Conditions	Process No.
MMBT 5179	TO-236 (49)	20	12	2.5	20	15	25	250	3	1	0.4		1.0	10	1		650	1700	2			40
MMBT H10	TO-236 (49)	30	25	3	100	25	60		4	10	0.5		0.95	4	0.35	0.65	650		4			42
MMBT 918	TO-236 (49)	30	15	3	10	15	20		3	1	0.4		1.0	10		1.7	600	1500	4	6	60	43
MMBT 3563	TO-236 (49)	30	15	2	50	15	20	200	8	10						1.7	600	1500	4			43
MMBT 5130	TO-236 (49)	30	12	1	50	10	15	250	8	10	0.6		1.0	10		1.7	450		8			43
MMBT H30	TO-236 (49)	20	20	3	50	10	20	200	4	5	0.3		0.96	10		0.5	300	800	4	6	45	44
MMBT 6543	TO-236 (49)	35	20	3	100	25	20		2	10	0.35			10			750		4			47
MMBT H11	TO-236 (49)	30	25	3	100	25	60		4	10	0.5			4	0.6	0.9	650		4			47
MMBT H24	TO-236 (49)	40	30	4	50	15	30		8	10						0.36	400		8			47
MMBT H34	TO-236 (49)	45	45	4	50	30	15 40		20 7	2 15	0.5			20		0.32	500		15			47
MMBT H20	TO-236 (49)	40	30	4	50	15	25		4	10						0.65	400		4			49
MMBT H81	TO-236 (49)																					

National Semiconductor

Surface Mount Transistors

Low Level Amplifiers—NPN

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{Ces} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
MMBT 930	TO-236 (49)	45	45	5	10	45		600	10	5	1.0	0.6	1.0	10	8	30		0.5	3	(Note 1)	11
							150		0.5	5											
							100	300	0.01	5											
MMBT 930A	TO-236 (49)	60	45	6	2	45	150		0.5	5	0.5	0.7	0.9	10	6	45		0.05	3	(Note 5)	11
							100	300	0.01	5											
							60		0.001	5											
								600	10	5											
MMBT 2484	TO-236 (49)	60	60	6	10	45	250		1	5	0.35			1	10	15		0.05	3	(Note 1)	11
							200		0.5	5											
							175		0.1	5											
							100	500	0.01	5											
							30		0.001	5											
MMBT 3117	TO-236 (49)	60	60	6	10	45	400		1	5	0.35			1	4.5	60		0.5	1	(Note 2)	11
							200		0.5	5											
							175		0.1	5											
							100	500	0.01	5											
							30		0.001	5											
MMBT 3565	TO-236 (49)	30	25	6	50	25	150	600	1	10	0.35			1	4	40	240	1			11
MMBT 4409	TO-236 (49)	80	50	5	10	60	60	400	10	1	0.2		0.8	1	12	60	300	10			11
MMBT 4410	TO-236 (49)	120	80	5	10	100	60	400	10	1	0.2		0.8	1	12	60	300	10			11
							60		1	1											
MMBT 5088	TO-236 (49)	35	30		50	20	300		10	5	0.5			10	4				3	(Note 3)	11
							350		1	5											
							300	900	0.1	5											
MMBT 5089	TO-236 (49)	30	25		50	15	400		10	5	0.5			10	4				2	(Note 3)	11
							450		1	5											
							400	1200	0.1	5											

Surface Mount Transistors

Low Level Amplifiers—NPN (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
MMBT 5133	TO-236	20	18	3	50	15	60	1000	1	5	0.4			1	5						11
	(49)																				
MMBT 5209	TO-236	50	50		50	35	150		10	5	0.7			10	4	30		0.5	4	(Note 5)	11
	(49)						150		1	5											
							100	300	0.1	5											
MMBT 5210	TO-236	50	50		50	35	250		10	5	0.7			10	4	30		0.5	3	(Note 4)	11
	(49)						250		1	5											
							200	600	0.1	5											
MMBT 5961	TO-236	60	60	8	2	45	100		0.01	5	0.2			10	6	100		10	6	(Notes 7, 11)	11
	(49)						120		0.1	5									3	(Note 10)	
							135		1	5									3	(Note 1)	
							150	700	10	5											
MMBT 5962	TO-236	45	45	8	2	30	450		0.01	5	0.2			10	6	100		10	6	(Notes 7, 11)	11
	(49)						500		0.1	5									4	(Note 8)	
							550		1	5									8	(Note 9)	
							600	1400	10	5									3	(Note 10)	
																			3	(Note 1)	

TEST CONDITIONS:

Note 1: $I_C = 10\ \mu A$, $V_{CE} = 8V$, $f = 10$ Hz -16.7 kHz

Note 2: $I_C = 10\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz

Note 3: $I_C = 5\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz

Note 4: $I_C = 100\ \mu A$, $V_{CE} = 5V$, $f = 10$ Hz $-$ 15.7 kHz

Note 5: $I_C = 10\ \mu A$, $V_{CE} = 5V$, $f = 10$ kHz

Note 6: $I_C = 100\ \mu A$, $V_{CE} = 6V$, $f = 5$ kHz

Note 7: $I_C = 100\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz, $R_S = 1\ k\Omega$

Note 8: $I_C = 100\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz, $R_S = 10\ k\Omega$

Note 9: $I_C = 100\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz, $R_S = 100\ k\Omega$

Note 10: $I_C = 10\ \mu A$, $V_{CE} = 5V$, $f = 1$ kHz, $R_S = 10\ k\Omega$

Note 11: $I_C/I_B = 20$

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Surface Mount Transistors

General Purpose Amplifiers and Switches—NPN

Type No.	Case Style	V_{CBO} (V)	V_{CEO} (V)	V_{EBO} (V)	I_{CBO} (nA) @	V_{CB} (V)	h_{FE}	@	I_C &	V_{CE}	$V_{B(SAT)}$ (V)	$V_{BE(SAT)}$ (V)	@	I_C	C_{ob} (pF)	f_T (MHz)	@	I_C (mA)	t_{off} (ns)	NF (dB)	Test Conditions	Process No.
		Min	Min	Min	Max		Min	Max	(mA)	(V)	Max	Min	Max	(mA)	Max	Min	Max		Max	Max		
MMBT 100	TO-236 (49)	75	45	6	50	60	80		0.1	1	0.2		0.85	10	4.5	250		20		4	(Note 1)	10
							100	450	10	1												
							100		100	1												
							100	350	150	1	0.4		1.0	200								
MMBT 100A	TO-236 (49)	75	45	6	50	60	300	600	10	1	0.2		0.85	10	4.5	250		20		4	(Note 1)	10
							100		100	1												
							220		0.1	5	0.4		1.0	200								
MMBT 101	TO-236 (49)	75	45	6	50	60	60		0.1	1	0.2		0.85	10	4.5	250		20		4	(Note 1)	10
							75	375	10	1												
							50		100	1												
MMBT 2218	TO-236 (49)	60	30	6	10	50	20		500	10	0.4		1.3	150	8	250		20				10
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		0.1	10	1.6		2.6	500								
MMBT 2218A	TO-236 (49)	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250		20	285		(Note 7)	10
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		0.1	10												
MMBT 2219	TO-236 (49)	60	30	5	10	50	30		500	10	0.4		1.3	150	8	300		20				10
							50		150	1												
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10	1.0		2.6	500								

Surface Mount Transistors

General Purpose Amplifiers and Switches—NPN (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 2219A	TO-236	75	40	6	10	60	40		500	10		0.6	1.2	150	8	300		20	285		(Note 2)	10
	(49)						50		150	1												
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10			2.0	500								
MMBT 2221	TO-236	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250		20				10
	(49)						20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
							20		0.1	10	1.6		2.6	500								
MMBT 2221A	TO-236	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	300		20	285		(Note 2)	10
	(49)						40	120	150	10												
							35		10	10												
							25		1	10												
							20		0.1	10	1.0		2.0	500								
MMBT 2222	TO-236	60	30	5	10	50	35		0.1	10	0.4	0.6	1.2	150	8	250		20				10
	(49)						50		1	10												
							75		10	10												
							100	300	150	10												
							30		500	10												
							50		150	1	1.6		2.6	500								
MMBT 2222A	TO-236	75	40	6	10	60	35		0.1	10	0.3	0.6	1.2	150	8	300		20		4	(Note 3)	10
	(49)						50		1	10												
							75		10	10												
							100	300	150	10												
							40		500	10												
							50		150	1	1.0		2.0	500								

Surface Mount Transistors

General Purpose Amplifiers and Switches—NPN (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 2484	TO-236	60	60	5	10	45	250		1	5	0.35			1	6					3	(Note 13)	10
	(49)							800	10	5												
MMBT 2924	TO-236	25	25	5	100	25	150	300	2	10					10							10
	(49)							(1 kHz)														
MMBT 3392	TO-236	25	25	5	100	18	150	300	2	4.5					10							10
	(49)																					
MMBT 3393	TO-226	25	25	5	100	18	90	180	2	4.5					10							10
	(49)																					
MMBT 3414	TO-226	25	25	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								10
	(49)																					
MMBT 3415	TO-226	25	25	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								10
	(49)																					
MMBT 3416	TO-226	50	50	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								10
	(49)																					
MMBT 3417	TO-226	50	50	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50								10
	(49)																					
MMBT 3566	TO-226	40	30	5	50	20	150	600	10	10	1.0			100	25	40		30				10
	(49)						80		2	10												
MMBT 3641	TO-226	60	30	5	50*	50	15		500	10	0.22			150	8	250		50				10
	(49)						40	120	150	10												
MMBT 3642	TO-226	60	45	5	50*	50	15		500	10	0.22			150	8	250		50				10
	(49)						40	120	150	10												
MMBT 3643	TO-226	60	30	5	50*	50	20		500	10	0.22			150	8	250		50				10
	(49)						100	300	150	10												

Surface Mount Transistors

General Purpose Amplifiers and Switches—NPN (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 5128	TO-236	15	12	3	50	10	35	350	50	10	0.25		1.1	150	10	150	800	50				10
	(49)						20		10	10												
MMBT 5135	TO-236	30	25	4	300	15	50	600	10	10	1.0		1.0	150	35	40	300	50				10
	(49)						15		2	10												
MMBT 5136	TO-236	30	20	3	100	20	20	400	150	1	0.25		1.0	150	35	40	400	50				10
	(49)						20		30	1												
MMBT 5137	TO-236	30	20	3	100	20	20	400	150	1	0.25		1.1	150	35	40	400	50				10
	(49)						20		30	1												
MMBT 5172	TO-236	25	25	5	100	25	100	500	10	10	0.25			10	10							10
	(49)																					
MMBT 5223	TO-236	25	20	3	100	10	50	800	2	10	0.7		1.2	10	4	150		10				10
	(49)																					
MMBT 6515	TO-236	40	25	4	50	30	250	500	2	10	0.5			5.0	3.5							10
	(49)						150		100	10												
MMBT 6520	TO-236	40	25	4	50	30	200	400	2	10	0.5			50	3.5					3	(Note 10)	10
	(49)						100		0.1	10												
MMBT 6521	TO-236	40	25	4	50	30	300	600	2	10	0.5				3.5					3	(Note 10)	10
	(49)						150		0.1	10												
MMBT A20	TO-236		40	4	100	30	40	400	5	10	0.25			10	4	125		5				10
	(49)																					

Surface Mount Transistors

General Purpose Amplifiers and Switches—NPN (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 4400	TO-236 (49)	60	40	6			20		1	1	0.4	0.75	0.95	150	6.5							13
							40		10	1	0.75		1.2	500								
MMBT 4401	TO-236 (49)	60	40	6			20		0.1	1	0.4	0.75	0.95	150	6.5	250		20				13
							40		1	1												
							80		10	1												
							100	300	150	1												
							40		500	2	0.75		1.2	500								
MMBT L01	TO-236 (49)	140	120	5	100	75	50	300	10	5	0.2		1.2	10	8	60		10				16
											0.3		1.4	50								
MMBT 5551	TO-236 (49)	180	160	6	50	120	80	250	10	5	0.15			10	6	100	300	10				16
							30		50	5	0.20		1.0	50								
MMBT 5830	TO-236 (49)	120	100	5	50	100	60		1	5	0.15		0.8	1	4	100	500	10				16
							80	500	10	5	0.2		1.0	10								
							80		50	5	0.25		1.0	50								
MMBT 5831	TO-236 (49)	160	140	5	50	100	60		1	5	0.15		0.8	1	4	100	500	10				16
							80	250	10	5	0.2		1.0	10								
							80		50	5	0.25		1.0	50								
MMBT 5833	TO-236 (49)	200	180	6	10	160	50		1	5	0.15		0.8	1	4	100	500	10				16
							50	250	10	5	0.2		1.0	10								
							50		50	5	0.25		1.0	50								
MMBT 5965	TO-236 (49)	200	180	5	50	160	50		1	5	0.15		0.8	1	4	100	500	10				16
							50	250	10	5	0.2		1.0	10								
							50		50	5	0.25		1.0	50								

Surface Mount Transistors

General Purpose Amplifiers and Switches—NPN (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 3693	TO-236 (49)	45	45	4	50	30	40	160	10	10					6	200	500	10				23
MMBT 3694	TO-236 (49)	45	45	4	50	30	100	400	10	10					6	200	500	10				23
MMBT 3903	TO-236 (49)	60	40	6			20		0.1	1	0.2	0.65	0.85	10	4	250		10		6	(Note 8)	23
							35		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.3		0.95	50								
MMBT 3904	TO-236 (49)	60	40	6			40		0.1	1	0.2	0.65	0.85	10	4	300		10		5	(Note 8)	23
							70		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.3		0.95	50								
MMBT 3946	TO-236 (49)	60	40	6			20		50	1	0.2	0.65	0.9	10	4	250		10	375	5	(Notes 6, 7)	23
							50	150	10	1												
							45		1	1												
							30		0.1	1	0.3		1.0	50								
MMBT 4123	TO-236 (49)	40	30	5	50	20	25		50	1	0.3		0.95	50	4	250		10		6	(Note 7)	23
							50	150	2	1												
MMBT 4124	TO-236 (49)	30	25	5	50	20	60		50	1	0.3		0.95	50	4	300		10		5	(Note 7)	23
							120	360	2	1												
MMBT 6514	TO-236 (49)	40	25	4	50	30	90		100	10	0.5			50	3.5							23
							150	300	2	10												

TEST CONDITIONS:

Note 1: $I_C = 300$ mA, $V_{CC} = 10V$, $I_B{}^1 = I_B{}^2 = 30$ mA
Note 2: $I_C = 150$ mA, $V_{CC} = 6V$, $I_B{}^1 = I_B{}^2 = 15$ mA
Note 3: $I_C = 300$ mA, $V_{CC} = 15V$, $I_B{}^1 = I_B{}^2 = 30$ mA
Note 4: $I_C = 300$ mA, $V_{CC} = 30V$, $I_B{}^1 = I_B{}^2 = 30$ mA
Note 5: $I_C = 10$ mA, $V_{CC} = 3V$, $I_B{}^1 = I_B{}^2 = 1$ mA
Note 6: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 100 Hz
Note 7: $I_C = 30\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 8: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 9: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 10: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 11: $I_C = 50$ mA, $V_{CC} = 30V$, $I_B{}^1 = I_B{}^2 = 5$ mA
Note 12: $I_C = 150$ mA, $V_{CC} = 30V$, $I_B{}^1 = I_B{}^2 = 15$ mA
Note 13: $I_C = 50$ mA, $V_{CC} = 10V$, $I_B{}^1 = I_B{}^2 = 5$ mA
Note 14: $I_C = 500$ mA, $V_{CC} = 30V$, $I_B{}^1 - I_B{}^2 = 50$ mA
Note 15: $I_C = 100\ \mu A$, $V_{CE} = 10V$, f = 1 kHz
Note 16: $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 17: $I_C/I_B = 40$
Note 18: $I_C/I_B = 20$
Note 19: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 10 Hz – 10 kHz
Note 20: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 100 Hz
Note 21: $I_C = 30\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 22: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 10 kHz
Note 23: $I_C = 1$ mA, $V_{CE} = 10V$, f = 1 MHz

National Semiconductor

Surface Mount Transistors

Medium Power—NPN

Type No.	Case Style	V_{CBO} (V) Min	V_{CER}* V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 3568	TO-236 (49)	80	60	5	50	40	40		30	1	0.25			150	20	60	600	50				12
							40	120	150	1												
MMBT 3700	TO-236 (49)	140	80	7	10	90	50		1	10	0.2		1.1	150	12	100	200	5				12
							90		10	10												
							100	300	150	10												
							50		500	10	0.5			500								
MMBT A05	TO-236 (49)	60	60	4	100	60	50		100	1	0.25			100		50		100				12
							50		10	1												
MMBT A06	TO-236 (49)	80	80	4	100	80	50		100	1	0.25			100		50		100				12
							50		10	1												
MMBT 3567	TO-236 (49)	80	40	5	50	40	40	120	30	1	0.25			150	20	60	600	50				13
							40		150	1												
MMBT 3569	TO-236 (49)	80	40	5	50	40	100	300	30	1	0.25			150	20	60	600	50				13
							100		150	1												
MMBT 6560	TO-236 (49)	25	25	5	100	20	35		10	1	0.5		1.2	500	30	60		10				38
							50		100	1												
							60	200	500	1												
MMBT 6561	TO-236 (49)	20	20	5	100	20	35		10	1	0.5		1.2	350	30	60		10				38
							50		100	1												
							50	200	500	1												
MMBT A42	TO-236 (49)	300	300	8	100	200	25		1	10	0.5		0.9	20		50		10				48
							40		10	10												
							40		30	10												
MMBT A43	TO-236 (49)	200	200	6	100	160	25		1	10	0.4		0.9	20		50		10				48
							40		10	10												
							50	200	30	10												

National Semiconductor

Surface Mount Transistors

Darlington Transistors—NPN

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	Process No.
MMBT 6426	TO-236	40	40	12	0.05	30	20,000	200,000	10	5	1.2			50	7	150		10	05
	(49)						30,000	300,000	100	5									
							20,000	300,000	500	5	1.5		2	500					
MMBT A12	TO-236	20		10	0.1	15	20,000		10	5	1.0			10					05
	(49)																		
MMBT A13	TO-236	30		10	0.1	30	5,000		10	5	1.5			100		125		10	05
	(49)						10,000		10	5									
MMBT A14	TO-236	30		10	0.1	30	10,000		10	5	1.5			100		125		10	05
	(49)						20,000		100	5									

National Semiconductor

Surface Mount Transistors

Saturated Switches—PNP

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA) ($I_B = \frac{I_C}{10}$)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	Test Conditions	Process No.
MMBT 3639	TO-236 (49)	6	6	4	50*	3	30	120	10	0.3	0.16			10	5.5	300		10	60	(Note 7)	65
							20		50	1	0.5			50							
MMBT 3640	TO-236 (49)	12	12	4	50*	6	20		50	1	0.2			10	5.5	300		10	75	(Note 7)	65
							30	120	10	0.3	0.6			50							
MMBT 4258	TO-236 (49)	12	12	4.5	10*	6	30	120	10	3	0.15	0.75	0.95	10	3	500		10	20	(Note 6)	65
							15		1	0.5											
							30		50	1	0.5		1.5	50							
MMBT 5228	TO-236 (49)	5	5	3	100*	4	30		10	3	0.4	0.65	1.25	10	5	300		10			65
MMBT 5771	TO-236 (49)	15	15	4.5	10	8	50	120	10	0.3	0.15		0.8	1	3	700		10	20	(Note 6)	65
							40		50	1	0.18	0.8	0.95	10							
							35		1	0.3	0.6		1.5	50							
MMBT 5771-1	TO-236 (49)	15	15	4.5	10	8	30	150	10	0.3	0.15		0.8	1	3	700		10	30	(Note 6)	65
							20		50	1	0.18	0.8	0.95	10							
							30		1	0.5	0.6		1.5	50							
MMBT 5571-2	TO-236 (49)	15	15	4.5	10	8	40	150	10	0.3	0.15		0.8	1	3	700		10	30	(Note 6)	65
							30		50	1	0.18	0.8	0.95	10							
							35		1	0.5	0.6		1.5	50							
MMBT 5910	TO-236 (49)	20	20	4.5	10*	10	30		50	1	0.15	0.75	0.95	10	3	700		10	20	(Note 6)	65
							30	120	10	0.3											
							15		1	0.5	0.5		1.5	50							

TEST CONDITIONS:

Note 1: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = 3$ mA, $I_B{}^2 = 1.5$ mA

Note 2: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = 3$ mA, $I_B{}^2 = 1$ mA

Note 3: $V_{CC} = 10V$, $I_C = 300$ mA, $I_B{}^1 = I_B{}^2 = 30$ mA

Note 4: $V_{CC} = 2V$, $I_C = 30$ mA, $I_B{}^1 = I_B{}^2 = 3$ mA

Note 5: $V_{CC} = 25V$, $I_C = 300$ mA, $I_B{}^1 = I_B{}^2 = 30$ mA

Note 6: $V_{CC} = 25V$, $I_C = 600$ mA, $I_B{}^1 = I_B{}^2 = 50$ mA

Note 7: $V_{CC} = 30V$, $I_C = 500$ mA, $I_B{}^1 - I_B{}^2 = 50$ mA

Note 8: $V_{CC} = 30V$, $I_C = 1A$, $I_B{}^1 = I_B{}^2 = 100$ mA

Note 9: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = I_B{}^2 = 1$ mA

Note 10: $V_{CC} = 10.7V$, $I_C = 1A$, $I_B{}^1 = I_B{}^2 = 100$ mA

Note 11: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = I_B{}^2 = 3$ mA

Note 12: $V_{CC} = 3V$, $I_C = 10$ mA, $I_B{}^1 = I_B2 = 3.3$ mA

National Semiconductor

Surface Mount Transistors

Low Level Amplifiers—PNP

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	NF (dB) Max	Test Conditions	Process No.
MMBT 4248	TO-236 (49)	40	40	5	10	40	50		0.1	5	0.25		0.9	10	6	40		0.5			69
							50		1	5											
							50		10	5											
MMBT 4249	TO-236 (49)	60	60	5	10	40	100	300	0.1	5	0.25		0.9	10	6	40		0.5	3	(Note 7)	69
							100		1	5									3	(Note 8)	
							100		10	5									3	(Note 9)	
MMBT 4250	TO-236 (49)	40	40	5	10	40	250	700	0.1	5	0.25		0.9	10	6	50		0.5	2	(Note 7)	69
							250		1.0	5									2	(Note 8)	
							250		10	5									2	(Note 9)	
MMBT 4250A	TO-236 (49)	60	60	5	10	50	250	700	0.1	5	0.25		0.9	10	6	50		0.5	2	(Note 7)	69
							250		1	5									2	(Note 8)	
							250		10	5									2	(Note 9)	
MMBT 5086	TO-236 (49)	50	50	5	10	10	150	500	0.1	5	0.3			10	4	40		0.5	3	(Note 4)	69
							150		1	5											
							150		10	5									3	(Note 3)	
MMBT 5087	TO-236 (49)	50	50	3	10	10	250	800	0.1	5	0.3			10	4	40		0.5	2	(Note 4)	69
							250		1	5											
							250		10	5									2	(Note 3)	
MMBT 5227	TO-236 (49)	30	30	3	100	10	30		0.1	10	0.4		1.0	10	5	100		10			69
							50	700	2	10											
MMBT A70	TO-236 (49)	40	40	4	100	30	40	400	5	10	0.25				50	4					69

TEST CONDITIONS:

Note 1: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 10 Hz–15.7 kHz

Note 2: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 10 kHz

Note 3: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 10 Hz–15.7 kHz

Note 4: $I_C = 20\ \mu A$, $V_{CE} = 5V$, f = 10 Hz–15.7 kHz

Note 5: $I_C/I_B = 20$

Note 6: $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz

Note 7: $I_C = 20\ \mu A$, $V_{CE} = 5V$, f = 10 Hz–10 kHz

Note 8: $I_C = 20\ \mu A$, $V_{CE} = 5V$, f = 1 kHz

Note 9: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 1 kHz

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Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP

Type No.	Case Style	V_{CBO}^* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 2904	TO-236 (49)	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50				63
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10	1.6		2.5	500								
MMBT 2904A	TO-236 (49)	60	40	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							100	300	150	10												
							100		10	10												
							100		1	10												
							75		0.1	10	1.6		2.6	500								
MMBT 2905	TO-236 (49)	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50				63
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10	1.6		2.6	500								
MMBT 2905A	TO-236 (49)	60	40	5	10	50	50		500	10	0.4		1.3	150	8	200		50	100		(Note 2)	63
							100	300	150	10												
							100		10	10												
							100		1	10												
							75		0.1	10	1.6		2.6	500								
MMBT 2906	TO-236 (49)	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50				63
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10	1.6		2.6	500								
MMBT 2906A	TO-236 (49)	60	40	5	10	50	50		500	10	0.4		1.3	150	8	200		500	100		(Note 2)	63
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10	1.6		2.6	500								

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 2907	TO-236 (49)	60	40	5	20	50	30		500	10	0.4		1.3	150	8	200		50				63
							100	300	150	10												
							75		10	10												
							50		1	10												
							35		0.1	10	1.6		2.6	500								
MMBT 2907A	TO-236 (49)	60	40	5	10	50	50		500	10	0.4		1.3	150	8	200		50		100	(Note 2)	63
							100	300	150	10												
							100		10	10												
							100		1	10												
							75		0.1	10	1.6		2.6	500								
MMBT 3638	TO-236 (49)	25	25	4	35*	15	20		10	10	0.25		1.1	50	20	100		50	170		(Notes 1, 18)	63
							30		50	1												
							20		300	2	1.0	0.8	2.0	300								
MMBT 3638A	TO-236 (49)	25	25	4	35*	15	100		10	10	0.25		1.1	50	10	150		50	170		(Notes 1, 18)	63
							80		1	10												
							100		50	1												
							20		300	2	1.0	0.8	2.0	300								
MMBT 3644	TO-236 (49)	45	45	5	35*	30	40		0.1	10	0.25		1.0	50	35	200		20	100		(Notes 4, 18)	63
							80		1	10												
							100		10	10												
							80	240	50	1	0.4		1.3	150								
							100	300	150	10												
							20		300	2	1.0	0.8	2.0	300								
MMBT 3645	TO-236 (49)	60	60	5	35*	50	40		0.1	10	0.25		1.0	50	35	200		20	100		(Notes 4, 18)	63
							80		1	10												
							100		10	10												
							80	240	50	1	0.4		1.3	150								
							100	300	150	1												
							20		300	2	1.0	0.8	2.0	300								

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 3702	TO-236 (49)	40	25	5	100	20	60	300	50	5	0.25			50	12	100		50				63
MMBT 3703	TO-236 (49)	50	30	5	100	20	30	150	50	5	0.25			50	12	100		50				63
MMBT 4402	TO-236 (49)	40	40	5			20		500	2	0.4	0.75	0.95	150	8.5	150		20	255		(Note 4)	63
							50	150	150	2												
							50		10	1												
							30		1	1	0.75		1.3	500								
MMBT 4403	TO-236 (49)	40	40	5			20		500	2	0.4	0.75	0.95	150	8.5	200		20	255		(Note 4)	63
							100	300	150	2												
							100		10	1												
							60		1	1												
							30		0.1	1	0.75		1.3	500								
MMBT 5142	TO-236 (49)	20	20	4	50*	12	15		300	10	0.5		1.5	50	10	100		50	200		(Note 1)	63
							30		50	1	2.0	0.8	2.5	300								
MMBT 5143	TO-236 (49)	20	20	4	50*	12	15		300	10	0.5		1.5	50	10	100		50	200		(Note 1)	63
							30		50	1	2.0	0.8	2.5	300								
MMBT 5226	TO-236 (49)	25	25	4	300	15	30	600	50	10	0.8		1.0	100	20	50		20				63
							25		10	10												
MMBT 6502	TO-236 (49)	60	40	5	20	50	35		0.1	10	0.4			150	8	200		50				63
							50		1	10												
							75		10	10												
							100	300	150	10												
							30		500	10	1.0			300								

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 3251	TO-236	50	40	5			30		50	1	0.25	0.6	0.9	10	6	300		10		6	(Note 6)	66
	(49)						100	300	10	1												
							80		0.1	1												
							90		0.001	1	0.5		1.2	50								
MMBT 3905	TO-236	40	40	5			30		0.1	1	0.25	0.65	0.85	10	4.5	200		10		5	(Note 8)	66
	(49)						40		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.4		0.95	50								
MMBT 3906	TO-236	40	40	5			60		0.1	1	0.25	0.65	0.85	10	4.5	200		10		4	(Note 8)	66
	(49)						80		1	1												
							100	300	10	1												
							60		50	1												
							30		100	1	0.4		0.95	50								
MMBT 4121	TO-236	40	40	5	25*	30	15		50	1	0.13		0.75	1	4.5	400		10	150	4	(Notes 8, 11)	66
	(49)						70	200	10	1	0.14	0.7	0.9	10								
							60		1	1												
							40		0.1	1	0.3		1.1	50								
MMBT 4122	TO-236	40	40	5	25*	30	30		50	1	0.13		0.75	1	4.5	200		10		5	(Note 8)	66
	(49)						150	300	10	1												
							150		1	1	0.14	0.7	0.9	10								
							100		0.1	1	0.3		1.1	50								

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	h_{FE} Min	h_{FE} Max @	I_C (mA) &	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 4125	TO-236	25	25	4	50	20	25		50	1	0.4		0.95	50	4.5	200		10		4	(Note 8)	66
	(49)						60	150	2	1												
MMBT 4126	TO-236	25	25	4	50	20	60		50	1	0.4		0.95	50	4.5	250		10		4	(Note 8)	66
	(49)						120	300	2	1												
MMBT 4916	TO-236	30	30	5	25*	15	15	200	50	1	0.13		0.75	1	4.5	400		10	150	4	(Notes 8, 13)	66
	(49)						70		10	1												
							60		1	1	0.14	0.7	0.9	10								
							40		0.1	1	0.3	0.75	1.1	50								
MMBT 4917	TO-236	30	30	5	25*	15	30		50	1	0.13		0.75	1	4.5	450		10	150	4	(Notes 8, 13)	66
	(49)						150	300	10	1												
							150		1	1	0.14	0.7	0.9	10								
							100		0.1	1	0.3	0.75	1.1	50								
MMBT 5138	TO-236	30	30	5	50*	20	50		10	10	0.2	0.7	1.0	10	5	300		10	200		(Note 13)	66
	(49)						50		1	10												
							50	800	0.1	10	0.5	0.75	1.25	50								
MMBT 5139	TO-236	20	20	5	50*	15	15		50	10	0.2	0.7	1.0	10	5	300		10	200		(Note 13)	66
	(49)						40		10	1												
							40		1	10												
							30		0.1	10	0.5	0.75	1.25	50								
MMBT 6518	TO-236	40	40	4	50	30	150	300	2	10	0.5			50	4							66
	(49)						90		0.1	10												
MMBT 4354	TO-236	60	60	5	50	5	25		0.1	10	0.15		0.9	150	30	100	500	50	400	3	(Notes 8, 14)	67
	(49)						40		1	10												
							50	500	10	10												
							40		100	10												
							30		500	10	0.5		1.1	500								

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 4355	TO-236	60	60	5	50	50	75		500	10	0.15		0.9	150	30	100	500	50	400	3	(Notes 8, 14)	67
	(49)						75		100	10												
							100	400	10	10	0.5		1.1	500								
							75		1	10												
							60		0.1	10	1.0		1.2	1A								
MMBT 4356	TO-236	60	60	5	50	50	30		500	10	0.15		0.9	150	30	100	500	50	400	3	(Notes 8, 14)	67
	(49)						40		100	10												
							50	250	10	10												
							40		1	10												
							25		0.1	10	0.5		1.1	500								
MMBT 5855	TO-236	60	60	5	100	40	50		10	10	0.4		1.3	150	15							67
	(49)						50	300	150	10												
							50		500	10												
							15		1A	10												
MMBT 5857	TO-236	80	80	5	100	60	50		10	10	0.4		1.3	150	15	100		50				67
	(49)						50	300	150	10												
							50		500	10												
							15		1A	10												
MMBT 6562	TO-236			5	100	20	50	200	500	1	0.5			500	30	60		10				67
	(49)						50		100	1												
							35		10	1												
MMBT A55	TO-236	60	60	4	100	60	50		10	1	0.25			100		50		100				67
	(49)						50		100	1												
MMBT A56	TO-236	80	80	4	100	80	50		10	1	0.25			100		50		100				67
	(49)						50		100	1												
MMBT 200	TO-236	60	45	6	50	50	80		0.1	1	0.2		0.85	10	6	250		20		4	(Note 8)	68
	(49)						100	450	10	1												
							100		100	1												
							100	350	150	5	0.4		1.0	200								

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 200A	TO-236 (49)	60	45	6	50	50	300	600	10	1	0.2		0.85	10	6	250		20				68
							100		100	1												
							250		0.1	1	0.4		1.0	200								
MMBT 201	TO-236 (49)	100	80	6	50*	60	60		0.1	1	0.2		0.85	10	4.5	100		10		4	(Note 8)	68
							75	375	10	1												
							50		100	1	0.4		1.0	100								
MMBT 3962	TO-236 (49)	60		6	10*	50	100		10	5	0.4		0.95	50	6							68
							90		50	5												
MMBT 4143	TO-236 (49)	60	40	6			30		500	10	0.4		1.3	150	8	200		50	100		(Note 12)	68
							60		150	1												
							100	300	100	10												
							75		10	10												
							60		1	10												
							25		0.1	10	1.6		2.6	500								
MMBT 4291	TO-236 (49)	40	30	6	200	30	100	300	100	10	0.4		1.5	100	10	100		10				68
							50		10	10												
							30		0.1	10												
MMBT 5447	TO-236 (49)	40	25	5			50	300	50	5	0.25			50	12	100		50				68

Surface Mount Transistors

General Purpose Amplifiers and Switches—PNP (Continued)

Type No.	Case Style	V_{CBO}* (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (mA)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	$V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
MMBT 3467	(TO-236)	40	40	5	100	30	40		1	5	0.3		1.0	150	25	175		50	90		(Note 4)	70
	(49)						40	100	500	1												
							40		150	1	0.5	0.8	1.2	500								
MMBT 4888	TO-236	150	150	6	50	100	30		1	10	0.5			10	4	30	160	1				74
	(49)						40	400	10	10												
MMBT 4889	TO-236	150	150	6	10	100	60		0.1	10	0.5			10	4	40	160	1		4	(Note 19)	74
	(49)						70		1	10										10	(Note 20)	
							80	300	10	10										3	(Note 21)	
																				3	(Note 22)	
																				4	(Note 23)	
MMBT 5400	TO-236	130	120	5	100	100	40		50	5	0.2		1.0	10	6	100	400	10		8	(Note 9)	74
	(49)						40	180	10	5												
							30		1	5	0.5		1.0	50								
MMBT 5401	TO-236	160	150	5	50	120	50		50	5	0.2		1.0	10	6	100	300	10		8	(Note 9)	74
	(49)						60	240	10	5												
							50		1	5	0.5		1.0	50								
MMBT L51	TO-236	100	100	4	1 μA	50	40	250	50	5	0.25		1.2	10	8	60		10				74
	(49)										0.3		1.2	50								
MMBT H81	TO-236	20	20	3	100	10	60		5	10	0.5			5	0.85	600		5				75
	(49)																					
MMBT A92	TO-236	300	300	5	250	200	25		1	10	0.5		0.9	20	6	50		10				76
	(49)						40		10	10												
							25		30	10												
MMBT A93	TO-236	200	200	5	250	160	25		1	10	0.5		0.9	20	8	50		10				76
	(49)						40		10	10												
							25	150	30	10												

TEST CONDITIONS:

Note 1: $I_C = 300$ mA, $V_{CC} = 10V$, $I_B^1 = I_B^2 = 30$ mA
Note 2: $I_C = 100$ mA, $V_{CC} = 5V$, $I_B^1 = I_B^2 = 15$ mA
Note 3: $I_C = 300$ mA, $V_{CC} = 15V$, $I_B^1 = I_B^2 = 30$ mA
Note 4: $I_C = 300$ mA, $V_{CC} = 30V$, $I_B^1 = I_B^2 = 30$ mA
Note 5: $I_C = 10$ mA, $V_{CC} = 3V$, $I_B^1 = I_B^2 = 1$ mA
Note 6: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 100 Hz
Note 7: $I_C = 30\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 8: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 9: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 10: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 11: $I_C = 50$ mA, $V_{CC} = 30V$, $I_B^1 = I_B^2 = 5$ mA
Note 12: $I_C = 150$ mA, $V_{CC} = 30V$, $I_B^1 = I_B^2 = 15$ mA
Note 13: $I_C = 50$ mA, $V_{CC} = 10V$, $I_B^1 = I_B^2 = 5$ mA
Note 14: $I_C = 500$ mA, $V_{CC} = 30V$, $I_B^1 = I_B^2 = 50$ mA
Note 15: $I_C = 100\ \mu A$, $V_{CE} = 10V$, f = 1 kHz
Note 16: $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 17: $I_C/I_B = 40$
Note 18: $I_C/I_B = 20$
Note 19: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 10 Hz–10 kHz
Note 20: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 100 Hz
Note 21: $I_C = 30\ \mu A$, $V_{CE} = 5V$, f = 1 kHz
Note 22: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 10 kHz
Note 23: $I_C = 1$ mA, $V_{CE} = 10V$, f = 1 MHz

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Surface Mount JFETs

N-Channel Switches/Choppers

Type No.	Case Style	BV_{GSS} BV_{GDO} (V) @	I_G	I_{GSS} $^*I_{DGO}$ (nA) @	V_{DG}	$I_{D(off)}$ (nA)@	V_{DS}	V_{GS}	V_P (V) @		V_{DS}	I_D	I_{DSS} (mA) @		V_{DS}	$r_{ds(on)}$ (Ω) @	I_D	C_{iss} (pF) @	V_{DS}	V_{GS}	C_{rss} (pF) @	V_{DS}	V_{GS}	t_{on} (ns)	t_{off} (ns)	Process No.
		Min	(μA)	Max	(V)	Max	(V)	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Max	(mA)	Max	(V)	(V)	Max	(V)	(V)	Max	Max	
MMBF 4391	TO-236 (49)	40	1	0.1	20	0.1	20	12	4	10	20	1	50	150	20	30	1	14	20	0	3.5	0	12	20	35	51
MMBF 4393	TO-236 (49)	40	1	0.1	20	0.1	20	5	0.5	3	20	1	5	30	20	100	1	14	20	0	3.5	0	5	20	80	51
MMBF J113	TO-236 (49)	40	1	0.1	20	0.1	20	5	0.5	3	5	1000	5	30	20	100	0.10	10t	0	10	15	0	10	13t	35t	51
MMBF 4391	TO-236 (49)	40	1	0.1	20	0.1	20	−12	4	10	20	1	50	150	20	30		14	20	0	3.5	0	−12	20	35	51
MMBF 4393	TO-236 (49)	40	1	0.1	20	0.1	20	−5	0.5	3	20	1	5	30	20	100		14	20	0	3.5	0	−5	55	130	51
MMBF J113	TO-236 (49)	35	1	1	15	1	5	−10	0.5	3	5	1000	2		15	100	1	10t	0	−10	15	0	−10	13t	35t	51

t = typical

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Surface Mount JFETs

N-Channel Wide Band—Low Noise Dual JFETs

Type No.	Case Style	Operating Conditions for These Characteristics											V_P (V)		I_{DSS} (mA)		G_{fs} (mmho)		G_{oss} (μmho)	I_{GSS} (pA @ V_{DG})		C_{iss} (pF)	C_{rss} (pF)	BV (V)	e_R (nV/$\sqrt{Hz}$) @ f		I_{DSS} Match	G_{fs} Match	G_{osc1-2} (μmho)	$I_{G1}-I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
		Op. Char. V_{DG} (V)	I_D (μA)	$\lvert V_{GS1-2}\rvert$ V_{OS} (mV) Max	Drift (μV/°C) ΔV_{GS} Max	I_G (pA) Max	G_{fs} μmhos Min	Max	G_{oss} (μmho) Max	CMRR (dB) Min	V_{gs} (V) Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	(V)	Min	Max	Min	Max	(Hz)	%	%				
MMBF 5911	8SOIC	10	5000	10	20	100	5000	10,000	100		0.3	4	1	5	7	40				100	16	5	1.2	25	20	10,000	5	5	20	20	93	S1
MMBF 5911	8SOIC	10	5000	10	20	100	5000	10,000	100		0.3	4	1	5	7	40				100	16	5	1.2	25	20	10,000	5	5	20	20	93	S1

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P-Channel JFETs

P-Channel Switches and Choppers

Type No.	Case Style	BV_{GSS} BV_{GDO} (V)	@ I_G	I_{GSS} $^*I_{DGO}$ (nA)	@ V_{DG}	$I_{D(off)}$ (nA)	@ V_{DS}	V_{GS}	V_P (V)		@ V_{DS}	I_D	I_{DSS} (mA)		@ V_{DS}	$r_{ds(on)}$ (Ω)	@ I_D	C_{iss} (pF)	@ V_{DS}	V_{GS}	C_{rss} (pF)	@ V_{DS}	V_{GS}	t_{on} (ns)	t_{off} (ns)	Process No.
		Min	(μA)	Max	(V)	Max	(V)	(V)	Min	Max	(V)	(nA)	Min	Max	(V)	Max	(mA)	Max	(V)	(V)	Max	(V)	(V)	Max	Max	
MMBFJ174	TO-236 (49)	30	1	1	20	1	15	10	5	10	15	0.1	20	100	15	85	0.1	11	0	10	5.5	0	10	2	5	88
MMBFJ175	TO-236 (49)	30	1	1	20	1	15	10	3	6	15	0.1	7	60	15	125	0.1	11	0	10	5.5	0	10	5	10	88
MMBFJ176	TO-236 (49)	30	1	1	20	1	15	10	1	4	15	0.1	2	25	15	250	0.1	11	0	10	5.5	0	10	15	15	88
MMBFJ177	TO-236 (49)	30	1	1	20	1	15	10	0.8	2.25	15	0.01	0.5	20	15	300	0.1	11	0	10	5.5	0	10	20	20	88

Section 7
Pro-Electron Series

Section 7 Contents

Diode Pro-Electron Series 7-3
Bipolar Pro-Electron Series 7-5
JFET Pro-Electron Series 7-26

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Diode Pro Electron Series

Part No.	V_{rrm} (V) Min	I_{rrm} (nA) Max	V_{fm} (V) Max	@ I_f (mA)	t_{rr} (ns) Max	Package
BA128	75	100	1.0	50		DO-35
BA129	200	50	1.0	100		DO-35
BA130	30	100	1.0	10		DO-35
BA217	30	50	1.0	10		DO-35
BA218	50	50	1.0	10		DO-35
BA316	10	200	0.85	10	4.0	DO-35
BA317	30	200	0.85	10	4.0	DO-35
BA318	50	200	0.85	10	4.0	DO-35
BAS16	75	1000	1.1	50	6.0	TO-236
BAS19	100	100	1.0	100	50	TO-236
BAS20	150	100	1.0	100	50	TO-236
BAS21	200	100	1.0	100	50	TO-236
BAS29	90		0.84	50		TO-236
BAS31	90		0.84	50		TO-236
BAS35	90		0.84	50		TO-236
BAV17	25	100	1.0	100	50	DO-35
BAV18	60	100	1.0	100	50	DO-35
BAV19	120	100	1.0	100	50	DO-35
BAV20	200	100	1.0	100	50	DO-35
BAV21	250	100	1.0	100	50	DO-35
BAV70	70	5000	1.1	50	6.0	TO-236
BAV74	50	100	1.0	100	4.0	TO-236
BAV99	70	2500	1.1	50	6.0	TO-236
BAW56	70	2500	1.1	50	6.0	TO-236
BAW62	75	25	1.0	100	4.0	DO-35
BAW75	35	100	1.0	30	2.0	DO-35
BAW76	75	100	1.0	100	2.0	DO-35
BAX13	50	200	1.0	20	4.0	DO-35
BAX16	180	100	1.5	200	120	DO-35

Diode Pro Electron Series (Continued)

Part No.	V_{rrm} (V) Min	I_{rrm} (nA) Max	V_{fm} (V) Max	@	I_f (mA)	t_{rr} (ns) Max	Package
BAY19	120	100	1.0		100	50	DO-35
BAY71	50	100	1.0		20	2.0	DO-35
BAY72	125	100	1.0		100	50	DO-35
BAY73	125	1.0	1.0		200	3.0	DO-35
BAY74	50	100	1.1		300	4.0	DO-35
BAY80	150	100	1.0		150	50	DO-35
BAY82	15	100	1.0		20	0.75	DO-7

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Bipolar Pro Electron Series

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC327	TO-92 (97)	50*	45	5	100*	45	40 100	 600	300 100	1 1	0.7		 1.2*	500 300								67
BC327A	TO-92 (97)	60*	60	5	100*	45	40 100	 400	300 100	1 1	0.7		 1.2*	300 500								67
BC327-10	TO-92 (97)	50*	45	5	100*	45	40 63	 160	300 100	1 1	0.7		 1.2*	500 300								67
BC327-16	TO-92 (97)	50*	45	5	100*	45	40 100	 250	300 100	1 1	0.7		 1.2*	500 300								67
BC327-25	TO-92 (97)	50*	45	5	100*	45	40 160	 400	300 100	1 1	0.7		 1.2*	500 300								67
BC328	TO-92 (97)	30*	25	5	100*	25	40 100	 600	300 100	1 1	0.7		 1.2	500 300								67
BC328-10	TO-92 (97)	30*	25	5	100*	25	40 63	 160	300 100	1 1	0.7		 1.2	500 300								67
BC328-16	TO-92 (97)	30*	25	5	100*	25	40 100	 250	300 100	1 1	0.7		 1.2	500 300								67
BC328-25	TO-92 (97)	30*	25	5	100*	25	40 160	 400	300 100	1 1	0.7		 1.2	500 300								67
BC337	TO-92 (97)	50*	45	5	100	20	100 40	600 	100 500	1 1	0.7			500								12
BC337A	TO-92 (97)	60*	60	5	100	20	100 40	400 	100 500	1 1	0.7			500								12
BC337-16	TO-92 (97)	50*	45	5	100	20	100 40	250 	100 500	1 1	0.7			500								12
BC337-25	TO-92 (97)	50*	45	5	100	20	160 40	400 	100 500	1 1	0.7			500								12

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}^* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC338	TO-92 (97)	30*	20	5	100	20	100	600	100	1	0.7			500								12
							40		500	1												
BC338-16	TO-92 (97)	30*	20	5	100	20	100	250	100	1	0.7			500								12
							40		500	1												
BC338-25	TO-92 (97)	30*	20	5	100	20	100	250	100	1	0.7			500								12
							40		500	1												
BC368	TO-92 (94)	25*	20	5	10 μA	25	60		5	10	0.5			1A								37
							85	375	500	1												
							60		1A	1												
BC369	TO-92 (94)	25*	20	5	10 μA	25	50		5	10	0.5			1A								77
							85	375	500	1												
							60		1A	1												
BC546	TO-92 (97)	80	65	6	15	30	110	800	2	5	0.25			10						10	(Notes 1, 11)	11
											0.6			100								
BC546A	TO-92 (97)	80	65	6	15	30	110		0.01	5	0.25			10						10	(Notes 1, 11)	11
								220	2	5	0.6			100								
BC546B	TO-92 (97)	80	65	6	15	30	200		0.01	5	0.25			10						10	(Notes 1, 11)	11
								450	2	5	0.6			100								
BC547	TO-92 (97)	50	45	6	10	20					0.25		0.77*	10	4.5					10	(Notes 1, 11)	10
											0.6			100								
							125	900*	2	5		0.55	0.70*	2								
BC547A	TO-92 (97)	50	45	6	10	20					0.25		0.77*	10	4.5					10	(Notes 1, 11)	10
											0.6			100								
							125	260*	2	5		0.55	0.70*	2								
BC547B	TO-92 (97)	50	45	6	10	20					0.25		0.77*	10	4.5					10	(Notes 1, 11)	10
											0.6			100								
							240	500*	2	5		0.55	0.70*	2								
BC547C	TO-92 (97)	50	45	5	15	30					0.25		0.77*	10	4.5					10	(Notes 1, 11)	10
											0.6			100								
							420	900	2	5		0.55	0.70*	2								

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) & Max	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC548	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					10	(Note 1)	10
	(97)										0.6			100								
							125	900*	2	5		0.55	0.70*	2								
BC548A	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					10	(Note 1)	10
	(97)										0.6			100								
							125	260*	2	5		0.55	0.70*	2								
BC548B	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					10	(Note 1)	10
	(97)										0.6			100								
							240	500*	2	5		0.55	0.70*	2								
BC548C	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					10	(Note 1)	10
	(97)										0.6			100								
							450	900*	2	5		0.55	0.70*	2								
BC549	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					4	(Note 1)	10
	(97)										0.6			100								
							240	900*	2	5		0.55	0.70*	2								
BC549B	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					4	(Note 1)	10
	(97)										0.6			100								
							240	500*	2	5		0.55	0.70*	2								
BC549C	TO-92	30	20	5	10	20					0.25		0.77*	10	4.5					4	(Note 1)	10
	(97)													100								
							450	900*	2	5		0.55	0.70*	2								
BC550	TO-92	50	45	5	10	45					0.25		0.77*	10						3	(Note 1)	10
	(97)										0.6			100								
							240	900*	2	5		0.55	0.70*	2								
BC550B	TO-92	50	45	5	10	45					0.25		0.77*	10						3	(Note 1)	10
	(97)										0.6			100								
							240	500*	2	5		0.55	0.70*	2								
BC556	TO-92	80	65	5	15	30	75	475	2	5	0.3			10						10	(Note 1)	69
	(97)										0.65			100								

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC556A	TO-92	80	65	5	15	30	125	250	2	5	0.3			10						10	(Note 1)	69
	(97)																					
											0.65			100								
BC556B	TO-92	80	65	5	15	30	220	475	2	5	0.3			10						10	(Note 1)	69
	(97)																					
											0.65			100								
BC557	TO-92	50	45	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							75	900*	2	5		0.6	0.75*	2								
BC557A	TO-92	50	45	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							125	260*	2	5		0.6	0.75*	2								
BC557B	TO-92	50	45	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75*	2								
BC558	TO-92	30	25	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							75	500*	2	5		0.6	0.75*	2								
BC558A	TO-92	30	25	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							125	260*	2	5		0.6	0.75	2								
BC558B	TO-92	30	25	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75	2								
BC558C	TO-92	30	25	5	100	20					0.3		0.82*	10						10	(Note 1)	68
	(97)										0.65			100								
							450	900*	2	5		0.6	0.75	2								
BC559	TO-92	25	20	5	100	20					0.3		0.82*	10						4	(Note 1)	68
	(97)										0.65			100								
							125	500*	2	5		0.6	0.75*	2								

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}^* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC559B	TO-92	25	20	5	100	20					0.3		0.82*	10						4	(Note 1)	68
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75*	2								
BC559C	TO-92	25	20	5	100	20					0.3		0.82*	10						4	(Note 1)	68
	(97)										0.65			100								
							450	900*	2	5		0.6	0.75*	2								
BC560	TO-92	50	45	5	100	45					0.3		0.82*	10						3	(Note 1)	68
	(97)										0.65			100								
							125	500*	2	5		0.6	0.75*	2								
BC560B	TO-92	50	45	5	100	45					0.3		0.82*	10						3	(Note 1)	68
	(97)										0.65			100								
							240	500*	2	5		0.6	0.75*	2								
BC635	TO-92	45	45	5			25		5	2	0.5			500								38
	(94)						40	250	150	2												
							25		500	2												
BC636	TO-92	45	45	5	100	30	25		5	2	0.5			500								78
	(94)						40	250	150	2												
							25		500	2												
BC637	TO-92	60	60	5			25		5	2	0.5			500								38
	(94)						40	250	150	2												
							25		500	2												
BC638	TO-92	60	60	5	100	30	25		5	2	0.5			500								78
	(94)						40	250	150	2												
							25		500	2												
BC639	TO-92	100	80	5			25		5	2	0.5			500								39
	(94)						40	250	150	2												
							25		500	2												
BC640	TO-92	100	80	5	100	30	25		5	2	0.5			500								79
	(94)						40	250	150	2												
							25		500	2												
BC807	TO-236	50*	45	5	100	20	100	600	100	1	0.7			500								67
	(49)						40		500	1												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC807-16	TO-236 (49)	50*	45	5	100	20	100 40	250	100 500	1 1	0.7			500								67
BC807-25	TO-236 (49)	50*	45	5	100	20	160 40	400	100 500	1 1	0.7			500								67
BC807-40	TO-236 (49)	50*	45	5	100	20	250 40	600	100 500	1 1	0.7			500								67
BC808	TO-236 (49)	30*	25	5	100	20	100 40	600	100 500	1 1	0.7			500								67
BC808-16	TO-236 (49)	30*	25	5	100	20	100 40	250	100 500	1 1	0.7			500								67
BC808-25	TO-236 (49)	30*	25	5	100	20	160 40	400	100 500	1 1	0.7			500								67
BC808-40	TO-236 (49)	30*	25	5	100	20	250 40	600	100 500	1 1	0.7			500								67
BC817	TO-236 (49)	30*	25	5	100	20	100 40	600	100 500	1 1	0.7			500								12
BC817-16	TO-236 (49)	30*	25	5	100	20	100 40	250	100 500	1 1	0.7			500								12
BC817-25	TO-236 (49)	30*	25	5	100	20	160 40	400	100 500	1 1	0.7			500								12
BC817-40	TO-236 (49)	30*	25	5	100	20	250 40	600	100 500	1 1	0.7			500								12
BC818	TO-236 (49)	30*	25	5	100	20	100 40	600	100 500	1 1	0.7			500								12
BC818-16	TO-236 (49)	30*	25	5	100	20	100 40	250	100 500	1 1	0.7			500								12
BC818-25	TO-236 (49)	30*	25	5	100	20	160 40	400	100 500	1 1	0.7			500								12

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC818-40	TO-236 (49)	30*	25	5	100	20	250	600	100	1	0.7			500								12
							40		500	1												
BC846	TO-236 (49)	80	65	6	15	30	110		0.01	5	0.25			10						10	(Note 1)	11
								800	2	5	0.6			100								
BC846-A	TO-236 (49)	80	65	6	15	30	110		0.01	5	0.25			10						10	(Note 1)	11
								220	2	5	0.6			100								
BC846-B	TO-236 (49)	80	65	6	15	30	200		0.01	5	0.25			10						10	(Note 1)	11
								450	2	5	0.6			100								
BC847	TO-236 (49)	50	45	6	15	30	110		0.01	5	0.25			10						10	(Note 1)	10
								800	2	5	0.6			100								
BC847-A	TO-236 (49)	50	45	6	15	30	110		0.01	5	0.25			10						10	(Note 1)	10
								220	2	5	0.6			100								
BC847-B	TO-236 (49)	50	45	6	15	30	200		0.01	5	0.25			10						10	(Note 1)	10
								450	2	5	0.6			100								
BC848	TO-236 (49)	30	30	5	15	30	110		0.01	5	0.25			10						10	(Note 1)	10
								800	2	5	0.6			100								
BC848-A	TO-236 (49)	30	30	5	15	30	110		0.01	5	0.25			10						10	(Note 1)	10
								220	2	5	6			100								
BC848-B	TO-236 (49)	30	30	5	15	30	200		0.01	5	0.25			10						10	(Note 1)	10
								450	2	5	6			100								
BC848-C	TO-236 (49)	30	30	5	15	30	420		0.01	5	0.25			10						10	(Note 1)	10
								800	2	5	6			100								

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC849	TO-236 (49)	30	30	5	15	30	200		0.01	5	0.25			10						4	(Note 1)	10
								800	2	5	6			100								
BC849B	TO-236 (49)	30	30	5	15	30	200		0.01	5	0.25			10						4	(Note 1)	10
								450	2	5	0.6			100								
BC849C	TO-236 (49)	30	30	5	15	30	420		0.01	5	0.25			10						4	(Note 1)	10
								800	2	5	0.6			100								
BC850	TO-236 (49)	50	45	5	15	30	200		0.01	5	0.25			10						3	(Note 1)	10
								800	2	5	0.6			100								
BC850-B	TO-236 (49)	50	45	5	15	30	200		0.01	5	0.25			10							(Note 1)	10
								450	2	5	6			100								
BC856	TO-236 (49)	80	65	5	15	30	75	475	2	5	0.3			10						10	(Note 1)	69
											0.65			100								
BC856-A	TO-236 (49)	80	65	5	15	30	125	250	2	5	0.3			10						10	(Note 1)	69
											0.65			100								
BC856-B	TO-236 (49)	80	65	5	15	30	220	475	2	5	0.3			10						10	(Note 1)	69
											0.65			100								
BC857	TO-236 (49)	50	45	5	15	30	75	475	2	5	0.3			10						10	(Note 1)	68
											0.65			100								
BC857-A	TO-236 (49)	50	45	5	15	30	125	250	2	5	0.3			10						10	(Note 1)	68
											0.65			100								

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) & Max	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BC857-B	TO-236 (49)	50	45	5	15	30	220	475	2	5	0.3			10						10	(Note 1)	68
											0.65			100								
BC858	TO-236 (49)	30	30	5	15	30	75	800	2	5	0.3			10						10	(Note 1)	68
											0.65			100								
BC858-B	TO-236 (49)	30	30	5	15	30	220	475	2	5	0.3			10						10	(Note 1)	68
											0.65			100								
BC858-C	TO-236 (49)	30	30	5	15	30	420	800	2	5	0.3			10						10	(Note 1)	68
											0.65			100								
BC859	TO-236 (49)	30	30	5	15	30	220	800	2	5	0.65			100						4	(Note 1)	68
BC859-A	TO-236 (49)	30	30	5	15	30	125	250	2	5	0.65			100						4	(Note 1)	68
BC859-B	TO-236 (49)	30	30	5	15	30	220	475	2	5	0.65			100						4	(Note 1)	68
BC859-C	TO-236 (49)	30	30	5	15	30	420	800	2	5	0.65			100						4	(Note 1)	68
BC860	TO-236 (49)	50	45	5	15	30	220	800	2	5	0.3			10						3	(Note 1)	68
											0.65			100								
BC860-B	TO-236 (49)	50	45	5	15	30	220	475	2	5	0.3			10						3	(Note 1)	68
											0.65			100								
BCF29	TO-236 (49)	32	32	5	100	32	120		0.01	5	0.3			10						4	(Note 1)	68
								260	2	5												
BCF30	TO-236 (49)	32	32	5	100	32	200		0.01	5	0.25			10						4	(Note 1)	68
								450	2	5												
BCF32	TO-236 (49)	50	45	5	100	20	215		0.01	5	0.3			10						4	(Note 1)	10
								500	2	5												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCF33	TO-236	50	45	5	100	20	200		0.01	5	0.3			10						4	(Note 1)	10
	(49)							450	2	5												
BCF70	TO-236	50	45	5	100	20	215		0.01	5	0.3			10						4	(Note 1)	10
	(49)							500	2	5												
BCV26	TO-236	40	30	10	100	30	4,000		1	5	1.0		1.5	100								61
	(49)						10,000		10	5												
							20,000		100	5												
BCV27	TO-236	40	30	10	100	30	4,000		1	5	1.0		1.5	100								05
	(49)						10,000		10	5												
							20,000		100	5												
BCV71	TO-236	80	60	5	100	20	110	220	2	5	0.25			10						10	(Note 1)	11
	(49)																					
BCV72	TO-236	80	60	5	100	20	200	450	2	5	0.25			10						10	(Note 1)	11
	(49)																					
BCW29	TO-236	32	32	5	100	32	120		0.01	5	0.3			10						10	(Note 1)	68
	(49)							260	2	5												
BCW30	TO-236	32	32	5	100	32	215		0.01	5	0.3			10						10	(Note 1)	68
	(49)							500	2	5												
BCW31	TO-236	32	32	5	100	32	150		0.01	5	0.25			10						10	(Note 1)	10
	(49)							270	2													
BCW32	TO-236	32	32	5	100	32	200		0.01	5	0.25			10						10	(Note 1)	10
	(49)							420	2													
BCW33	TO-236	32	32	5	100	32	450		0.01	5	0.25			10						10	(Note 1)	10
	(49)							800	2													
BCW60	TO-236	32*	32	5	20	32	50		50	1	0.35	0.6	0.85	50		125		10		6	(Note 1)	10
	(49)						120	630	2	5												
BCW61	TO-236	32*	32	5	20	32	50		50	1	0.25	0.6	0.85	50						6	(Note 1)	68
	(49)						120	630	2	5												
BCW65	TO-236	60	32	5	20*	32	35		0.1	10			2.0	500	12	100		20		10	(Note 1)	10
	(49)						75	220	10	1												
							100	250	100	1												
							35		500	1												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}^* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCW66	TO-236 (49)	75	45	5	20*	45	35		0.1	10			2.0	500	12	100		20		10	(Note 1)	10
							75		10	1												
							100	250	100	1												
							35		500	1												
BCW68	TO-236 (49)	75	45	5	20*	45	35		0.1	10			2.0	500	12	100		20		10	(Note 1)	10
							75		10	1												
							100	250	100	1												
							35		500	1												
BCW69	TO-236 (49)	50	45	5	100	20	120	260	2	5	0.3			10						10	(Note 1)	68
BCW70	TO-236 (49)	50	45	5	100	20	215	500	2	5	0.3			10						10	(Note 1)	68
BCW71	TO-236 (49)	50	45	5	100	20	110	220	2	5	0.25			10						10		68
BCW72	TO-236 (49)	50	45	5	100	20	200	450	2	5	0.25			10						10	(Note 1)	68
BCW81	TO-236 (49)	50	45	5	100	20	420	800	2	5	0.25			10						10	(Note 1)	10
BCW89	TO-236 (49)	80	60	5	100	20	120	260	2	5	0.3			10						10	(Note 1)	68
BCX17	TO-236 (49)	50*	45	5	100	20	100	600	100	1	0.62			500								67
							70		300	1												
							40		500	1												
BCX18	TO-236 (49)	30*	25	5	100	20	100	600	100	1	0.62			500								67
							70		300	1												
							40		500	1												
BCX19	TO-236 (49)	50*	45	5	100	20	100	600	100	1	0.62		1.2	500								12
							70		300	1												
							40		500	1												
BCX20	TO-236 (49)	30*	25	5	100	20	100	600	100	1	0.62		1.2	500								12
							70		300	1												
							40		500	1												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCX58	TO-92		32	7	10	32	120	630	2	5						125		10	800	6	(Notes 3 & 4)	10
	(97)						80	1000	10	1												
							40		100	1												
BCX58-7	TO-92		32	7	10	32	120	220	2	5						125		10	800	6	(Notes 3 & 4)	10
	(97)						80		10	1												
							40		100	1												
BCX58-8	TO-92		32	7	10	32	20		0.01	5						125		10	800	6	(Notes 3 & 4)	10
	(97)						180	310	2	5												10
							120	400	10	1												
							45		100	1												
BCX58-9	TO-92		32	7	10	32	40		0.01	5						125		10	800	6	(Notes 3 & 4)	10
	(97)						250	460	2	5												
							160	630	10	1												
							60		100	1												
BCX58-10	TO-92		32	7	10	32	100		0.01	5						125		10	800	6	(Notes 3 & 4)	10
	(97)						380	630	2	5												
							240	1000	10	1												
							60		100	1												
BCX59	TO-92		45	7			120	630	2	5	0.5		1.0	100		125		10	800		(Note 5)	10
	(97)						80	1000	10	1												
							40		100	1												
BCX59-7	TO-92		45	7			120	220	2	5	0.5		1.0	100		125		10	800		(Note 5)	10
	(97)						80		10	1												
							40		100	1												
BCX59-8	TO-92		45	7			20		0.01	5	0.5		1.0	100		125		10	800		(Note 5)	10
	(97)						180	310	2	5												
							120	400	10	1												
							45		100	1												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) & Max	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCX59-9	TO-92 (97)		45	7			40		0.01	5	0.5		1.0	100		125		10	800		(Note 5)	10
							250	460	2	5												
							160	630	10	1												
							60		100	1												
BCX59-10	TO-92 (97)		45	7			100		0.01	5	0.5		1.0	100		125		10	800		(Note 5)	10
							380	630	2	5												
							240	1000	10	1												
							60		100	1												
BCX70G	TO-236 (49)	45	45	5	20	32	120	220	2	5	0.55	0.7	1.05	50	4.5	125		10	800	6	(Notes 17, 19)	10
							60		50	1												
BCX70H	TO-236 (49)	45	45	5	20	32	180	310	2	5	0.55	0.7	1.05	50	4.5	125		10	800	6	(Notes 17, 19)	10
							70		50	1												
							20		0.01	5												
BCX70J	TO-236 (49)	45	45	5	20	32	250	460	2	5	0.55	0.7	1.05	50	4.5	125		10	800	6	(Notes 17, 19)	10
							90		50	1												
							40		0.01	5												
BCX71G	TO-236 (49)	45	45	5	20	32	120	220	2	5	0.55	0.7	1.05	50	4.5	125		10	800	6	(Notes 17, 19)	68
							60		50	1												
BCX71H	TO-236 (49)	45	45	5	20	32	180	310	2	5	0.55	0.7	1.05	50	4.5	125		10	800	6	(Notes 17, 19)	68
							70		50	1												
							20		0.01	5												
BCX71J	TO-236 (49)	45	45	5	20	32	250	460	2	5	0.55	0.7	1.05	50	4.5	125		10	800	6	(Notes 17, 19)	68
							90		50	1												
							40		0.01	5												
BCX78	TO-92 (97)		32	5			120	630	2	5	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							80	1000	10	1												
							40		100	1												
BCX78-7	TO-92 (97)		32	5			120	220	2	5	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							80		10	1												
							40		100	1												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BCX78-8	TO-92 (97)		32	5			30		0.01	5	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							180	310	2	5												
							120	400	10	1												
							45		100	1												
BCX78-9	TO-92 (97)		32	5			40		0.01	5	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							250	460	2	5												
							160	630	10	1												
							60		100	1												
BCX78-10	TO-92 (97)		32	5			100		0.01	5	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							380	630	2	5												
							240	1000	10	1												
							60		100	1												
BCX79	TO-92 (97)		45	5			80	1000	10	1	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							40		100	1												
							120	630	2	5												
BCX79-7	TO-92 (97)		45	5			120	220	2	5	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
BCX79-8	TO-92 (97)		45	5			120	400	10	1	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							45		100	1												
							30		0.01	5												
							180	310	2	5												
BCX79-9	TO-92 (97)		45	5			160	630	10	1	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							60		100	1												
							40		0.01	5												
							250	460	2	5												
BCX79-10	TO-92 (97)		45	5			240	1000	10	1	0.6		1.0	100	4.5	200		10		6	(Note 1)	68
							60		100	1												
							100		0.01	5												
							380	630	2	5												
BD370A	TO-237 (91)	80	45		100	45	25		500	2	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
							40	400	100	1												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD370A-10	TO-237 (91)	80	45		100	45	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370A-16	TO-237 (91)	80	45		100	45	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370A-25	TO-237 (91)	80	45		100	45	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370B	TO-237 (91)	80	60		100	60	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370B-10	TO-237 (91)	80	60		100	60	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370B-16	TO-237 (91)	80	60		100	60	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370B-25	TO-237 (91)	80	60		100	60	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370C	TO-237 (91)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370C-6	TO-237 (91)	80	80		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370C-10	TO-237 (91)	80	80		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370C-16	TO-237 (91)	80	80		100	80	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD370D	TO-237 (91)	80	100		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD370D-6	TO-237 (91)	80	100		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD370D-10	TO-237 (91)	80	100		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371A	TO-237 (91)	80	45		100	45	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD371A-10	TO-237 (91)	80	45		100	45	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371A-16	TO-237 (91)	80	45		100	45	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371A-25	TO-237 (91)	80	45		100	45	25 180	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371B	TO-237 (91)	80	60		100	60	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371B-10	TO-237 (91)	80	60		100	60	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371B-16	TO-237 (91)	80	60		100	60	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371B-25	TO-237 (91)	80	60		100	60	25 160	 400	500 100	2	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371C	TO-237 (91)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371C-6	TO-237 (91)	80	80		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371C-10	TO-237 (91)	80	80		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371C-16	TO-237 (91)	80	80		100	80	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD371D	TO-237 (91)	80	100		100	100	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	39
BD371D-6	TO-237 (91)	80	100		100	100	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	39
BD371D-10	TO-237 (91)	80	100		100	100	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	39
BD372A	TO-237 (90)	80	45		100	45	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) & Max	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD372A-10	TO-237 (90)	80	45		100	45	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372A-16	TO-237 (90)	80	45		100	45	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372A-25	TO-237 (90)	80	45		100	45	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372B	TO-237 (90)	80	60		100	60	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372B-10	TO-237 (90)	80	60		100	60	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372B-16	TO-237 (90)	80	60		100	60	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372B-25	TO-237 (90)	80	60		100	60	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372C	TO-237 (90)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372C-6	TO-237 (90)	80	80		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372C-10	TO-237 (90)	80	80		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372C-16	TO-237 (90)	80	100		100	100	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	78
BD372D	TO-237 (90)	80	100		100	100	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	79
BD372D-6	TO-237 (90)	80	100		100	100	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	79
BD372D-10	TO-237 (90)	80	100		100	100	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	79
BD373A	TO-237 (90)	80	45		100	45	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BD373A-10	TO-237 (90)	80	45		100	45	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373A-16	TO-237 (90)	80	45		100	45	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373A-25	TO-237 (90)	80	45		100	45	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373B	TO-237 (90)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373B-10	TO-237 (90)	80	60		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373B-16	TO-237 (90)	80	60		100	60	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373B-25	TO-237 (90)	80	60		100	60	25 160	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373C	TO-237 (90)	80	80		100	80	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373C-6	TO-237 (90)	80	80		100	80	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373C-10	TO-237 (90)	80	80		100	80	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373C-16	TO-237 (90)	80	80		100	80	25 100	 250	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373D	TO-237 (90)	80	100		100	100	25 40	 400	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373D-6	TO-237 (90)	80	100		100	100	25 40	 100	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BD373D-10	TO-237 (90)	80	100		100	100	25 63	 160	500 100	2 1	0.7		1.2*	1A	30	50		200	420	6	(Notes 5 & 6)	38
BF240	TO-92 (98)	40	40	4	100	20	65 6	225	1 12	10 7		0.65	0.74*	1	0.34			1		3.5	(Note 7)	47

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max @	V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max @	I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max &	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max @	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max @	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BF241	TO-92 (98)	40	40	4	100	20	35	125	1	10		0.65	0.74*	1	0.34			1		3.5	(Note 7)	47
							6		12	7												
BF494	TO-92 (98)	30	20	5			65	220	1	10												49
BF495	TO-92 (98)	30	20	5			35	250	1	10												49
BF536	TO-236 (49)	30	30	4	50	20	25		1	10												42
BF840	TO-236 (49)	40	40	4	100	20	65	220	1	10												47
BF841	TO-236 (49)	40	40	4	100	20	35	125	1	10												47
BF936	TO-92 (97)	30	20	4	50	20	25		1	10										6	(Note 7)	75
BFS18	TO-236 (49)	30	30	5	100	20	35	125	1	10												49
BFS19	TO-236 (49)	30	30	5	100	25	65	225	1	10												49
BSR13	TO-236 (49)	60	30	5	30	50	35		0.1	10	0.4		1.3	150	8	250		20				19
							50		1	10												
							75		10	10												
							100	300	150	10	1.6		2.6	500								
							50		150	1												
							30		500	10												
BSR14	TO-236 (49)	75	40	6	10	60	35		0.1	10	0.3	0.6	1.2	150	8	300		20				19
							50		1	10												
							75		10	10	1.0		2.0	500								
							100	300	150	10												
							50		150	1												
							40		500	10												

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BSR15	TO-236	60	40	5	20	50	35		0.1	10	0.4		1.3	150	8	200		50	100		(Note 9)	63
	(49)						50		1	10												
							75		10	10	1.6		2.6	500								
							100	300	150	10												
							30		500	10												
BSR16	TO-236	60	60	5	10	50	75		0.1	10	0.4		1.3	150	8	200		50	100		(Note 9)	63
	(49)						100		1	10												
							100		10	10	1.6		2.6	500								
							100	300	150	10												
							50		500	10												
BSR17	TO-236	60	40	6	5 μA	50	20		0.1	1	0.2	0.65	0.85	10		250		20	250		(Note 5)	23
	(49)						35		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.3		0.95	50								
BSR18	TO-236	60	40	6	5 μA	50	20		0.1	1	0.2	0.65	0.85	10		200		20	300		(Note 5)	66
	(49)						35		1	1												
							50	150	10	1												
							30		50	1												
							15		100	1	0.3		0.95	50								
BSR19	TO-236	160	140	6	100	100	60		1	5	0.15		1.0	10	6	100	300	10		10	(Note 16)	16
	(49)						60		10	5												
							20	250	50	5	0.25		1.2	50								
BSR20	TO-236	130	120	5	100	100	30				0.2		1.0	10	6	100	400	10		8	(Note 16)	16
	(49)						40	180	10	5												
							40		50	5	0.5		1.0	50								
BSS38	TO-236	120	100	5	200	90	20		4	1	0.7			4		60		4	1000		(Notes 17, 18)	16
	(49)										3.0		1.2	50								
BSS63	TO-236	110	100	6	100	90	30		10	1	0.25		0.9	25		50		25				74
	(49)						30		25	1												
BSS64	TO-236	120	80	5	100	90	20		10	1	0.15		1.2	4		60		4	1000		(Note 5)	16
	(49)										0.2			50								

Bipolar Pro Electron Series (Continued)

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} h_{fe} 1 kHz* Min	H_{FE} h_{fe} 1 kHz* Max	@ I_C (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}$* (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Conditions	Process No.
BSS79-B	TO-236	60	40	5	10	50	40	120	150	10	0.4			150	6	200		20				19
	(49)										1.6			500								
BSS79-C	TO-236	60	40	5	100	50	100	300	150	10	0.4			150	6	200		20				19
	(49)										1.6			500								
BSS80-B	TO-236	60	40	5	10	50	40	120	150	10	0.4			150	8	200		20				63
	(49)										1.6			500								
BSS80-C	TO-236	60	40	5	100	50	100	300	150	10	0.4			150	8	200		20				63
	(49)										1.6			500								
BSV52	TO-236	20	12	5	100	10	25		1	1	0.3			10		400		10	18		(Note 18)	21
	(49)						40	120	10	1	0.25	0.7	0.85	10								
								25	50	1	0.4		1.2	50								
BSX39	TO-236		14		100	12	25		1	1	0.25	0.7	0.85	10					18		(Note 1)	21
	(49)						40	200	10	1												
							25		50	1	0.4		1.2	5								

TEST CONDITIONS:

Note 1: $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 1 kHz.

Note 2: $I_C = 100$ mA, $V_{CC} = 20V$, $I_B^1 = I_B^2 = 5$ mA.

Note 3: $I_C = 200\ \mu A$, $V_{CE} = 2V$, f = 1 kHz.

Note 4: $I_C = 100$ mA, $V_{CC} = 10V$, $I_B^1 = I_B^2 = 10$ mA.

Note 5: $I_C = 10$ mA, $V_{CC} = 3V$, $I_B^1 = I_B^2 = 1$ mA.

Note 6: $I_C = 100\ \mu A$, $V_{CE} = 5V$, f = 1 kHz.

Note 7: $I_C = 1$ mA, $V_{CE} = 10V$, f = 200 MHz.

Note 8: $I_C = 1$ mA, $V_{CE} = 5V$, f = 1 kHz.

Note 9: $I_C = 150$ mA, $V_{CC} = 6V$, $I_B^1 = I_B^2 = 15$ mA.

Note 10: $I_C = 10\ \mu A$, $V_{CE} = 5V$, f = WB.

Note 11: $I_C/I_B = 20$.

Note 12: $I_C = 200\ \mu A$, $V_{CE} = 5V$, f = 30 Hz to 15 kHz.

Note 13: $I_C/I_B = 40$.

Note 14: $I_C/I_B = 1000$.

Note 15: $I_C/I_B = 33$.

Note 16: $I_C = 250\ \mu A$, $V_{CE} = 5V$, f = 10 Hz to 15.7 kHz.

Note 17: $I_C = 15$ mA, $I_B^1 = I_B^2 = 1$ mA.

Note 18: $I_C/I_B = 3.3$.

Note 19: $I_{CE} = 200\ \mu A$, $V_{CE} = 5V$, f = 200 Hz.

National Semiconductor

JFET Pro Electron Series

Type No.	Case Style	BV_{GSS} BV_{GDO} (V)	@ I_G (μA)	I_{GSS} I_{DGD} (nA)	@V_{GD} (V)	V_P (V) @		V_{DS} (V)	I_D (nA)	V_{GS} (V) @		V_{GS} (V)	I_D (μA)	I_{DSS} (mA)		@V_{DS} (V)	$R_e(Y_{FS})$ (mmho) @		f (MHz)	C_{iss} (pF)	@V_{DS} (V)	V_{GS} (V)	C_{rss} (pF)	@V_{DS} (V)	V_{GS} (V)	NF (dB) @ $R_G = 1k$ e_n*		f (Hz)*	Process No.	Pkg. No.
		Min		Max		Min	Max			Min	Max			Min	Max		Min	Max		Typ			Typ			Max	Typ	(MHz)		
BF244A	TO-92	30	1	5	20	0.5	8	15	10	0.4	2.2	15	200	2	6.5	15	3	6.5	0.001	4	20	−1	1.1	20	−1		1.5	100	50	94
BF244B	TO-92	30	1	5	20	0.5	8	15	10	1.6	3.8	15	200	6	15	15	3	6.5	0.001	4	20	−1	1.1	20	−1		1.5	100	50	94
BF244C	TO-92	30	1	5	20	0.5	8	15	10	3.2	7.5	15	200	12	25	15	3	6.5	0.001	4	20	−1	1.1	20	−1		1.5	100	50	94
BF245A	TO-92	30	1	5	20	0.5	8	15	10	0.4	2.2	15	200	2	6.5	15	3	6.5	0.001	4	20	−1	1.1	20	−1				50	97
BF245B	TO-92	30	1	5	20	0.5	8	15	10	1.6	3.8	15	200	6	15	15	3	6.5	0.001	4	20	−1	1.1	20	−1				50	97
BF245C	TO-92	30	1	5	20	0.5	8	15	10	3.2	7.5	15	200	12	25	15	3	6.5	0.001	4	20	−1	1.1	20	−1				50	97
BF246A	TO-92	25	1	5	15	0.6	14.5	15	10	1.5	4.0	15	200	30	80	15	8		0.001	11	(Note 1)5	0	3.5	15	0				51	94
BF246B	TO-92	25	1	5	15	0.6	14.5	15	10	3.0	7.0	15	200	60	140	15	8		0.001	11	(Note 1)5	0	3.5	15	0				51	94
BF246C	TO-92	25	1	5	15	0.6	14.5	15	10	5.5	12	15	200	110	250	15	8		0.001	11	(Note 1)5	0	3.5	15	0				51	94
BF247A	TO-92	25	1	5	15	0.6	14.5	15	10	1.5	4.0	15	200	30	80	15	8		0.001	11	(Note 1)5	0	3.5	15	0				51	97
BF247B	TO-92	25	1	5	15	0.6	14.5	15	10	3.0	7.0	15	200	60	140	15	8		0.001	11	(Note 1)5	0	3.5	15	0				51	97
BF247C	TO-92	25	1	5	15	0.6	14.5	15	10	5.5	12	15	200	110	250	15	8		0.001	11	(Note 1)5	0	3.5	15	0				51	97
BF256A	TO-92	30	1	5	20					0.5	7.5	15	200	3	7	15	4.5		0.001				0.7	20	−1		7.5	800	50	97
BF256B	TO-92	30	1	5	20					0.5	7.5	15	200	6	13	15	4.5		0.001				0.7	20	−1		7.5	800	50	97
BF256C	TO-92	30	1	5	20					0.5	7.5	15	200	11	18	15	4.5		0.001				0.7	20	−1		7.5	800	50	97
BSR56	SOT23	40	1	1	20	4	10	15	1					50		15							5	10	0				51	49
BSR57	SOT23	40	1	1	20	2	6	15	1					20	100	15							5	10	0				51	49
BSR58	SOT23	40	1	1	20	0.8	4	15	1					8	80	15							5	10	0				51	49

Section 8
Consumer Series

Section 8 Contents

Consumer Series 8-3

Consumer Series

Type No.	Case Style	V_{CES}* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* I_{CBO} @ (nA) Max	V_{CB} (V)	H_{FE} @ Min	H_{FE} Max	I_C & (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) & Max	$V_{BE(SAT)}$ $V_{BE(ON)}$* @ (V) Min	V_{BE} (V) Max	I_C (mA)	C_{ob} (pF) Max	f_T (MHz) @ Min	f_T Max	I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Condition	Process No.
CS9011	TO-92 (92)	40	30	5	100	30	39	198	1	5	0.3		0.75	10	3.5	150		1		4	(Note 4)	23
CS9012	TO-92 (92)	40	25	5	100	25	64	202	50	1	0.6		1.2	300								68
CS9013	TO-92 (92)	40	25	5	100	25	64	202	50	1	0.6		1.2	300								10
CS9014	TO-92 (92)	50	40	5	50	30	60	600	1	5	0.3		1	10	4.5	100		10		10	(Note 5)	07
CS9015	TO-92 (92)	50	40	5	50	30	60	600	1	5	0.3		1	10	6.0	100		10		10	(Note 5)	62
CS9016	TO-92 (92)	30	20	5	50	20	28	146	1	5	0.3		1	10	1.6	300		1		5	(Note 6)	49
CS9018	TO-92 (92)	30	15	5	50	20	28	146	1	5	0.3		1	10	1.7	400		2				43
ED1402	TO-92 (92)	35	30	4	10	10	110	810	2	5										10	(Note 7)	11
ED1502	TO-92 (92)	25	20	4	10	10	36	210	1	10						350		5				49
ED1602	TO-92 (92)	35	30	4	10	10	70	475	2	5										10	(Note 7)	69
ED1702	TO-92 (92)	30*	25	5	100*	20	40 106	 300	0.5A 100	1 1	0.4			500								37
ED1802	TO-92 (92)	30*	25	5	100*	20	40 106	 300	0.5A 100	1 1	0.4			500								77
SA733	TO-92 (94)	60	50	50	100	50	90	600	1	6	0.3			100	6	150		10		20		69
SA1015	TO-92 (94)	50	50	5	100	40	70 25	400	2 150	6 6	0.3			100	7					10		69

Consumers Series (Continued)

Type No.	Case Style	V_{CES}^* V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* I_{CBO} (nA) Max	@ V_{CB} (V)	H_{FE} Min	H_{FE} Max	@ I_C & (mA)	V_{CE} (V)	$V_{CE(SAT)}$ (V) & Max	$V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Min	$V_{BE(SAT)}$ $V_{BE(ON)}^*$ (V) Max	@ I_C (mA)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (mA)	t_{off} (ns) Max	NF (dB) Max	Test Condition	Process No.
SC945	TO-92 (94)	60	50	5	100	50	90	600	1	6	0.3			100	4	150		10		20		11
SC1815	TO-92 (94)	60	50	5	100	50	70 25	400	2 150	6 6	0.3			100	4					10		11
NA11	TO-92 *	25	20	5	1μA	20	30	350	100	3	0.5		1.0	400	4.5	50		100			(Note 2)	10
NA12	TO-92 *	25	20	5	1μA	20	30	350	100	3	0.5		1.0	400	7	50		100			(Note 2)	68
NA31	TO-92 *	35	30	5	1μA	30	30	350	300	5	0.5		1.2	1.2A	10	20		300			(Note 2)	37
NA32	TO-92 *	35	30	5	1μA	30	30	350	300	5	0.5		1.2	1.2A	17	20		300			(Note 2)	77
NB111	TO-92 *	40	35	6	100	35	100	350	15	5	0.4		0.95	20	4	100		15			(Note 3)	11
NB121	TO-92 *	40	35	6	100	35	100	350	15	5	0.4		0.95	20	6	100		15			(Note 3)	69
NR421	TO-92 (96)	35	30	3	100	30	20	240	2	5	0.3		0.95	10	1.3	450		2			(Note 1)	42
NR431	TO-92 *	18	15	3	100	15	20	240	1	5	0.3		0.95	10	1.7	350		1			(Note 1)	43
SS8050	TO-92 (92)	40	25	6	100	35	45 85 40	 300 	5 100 800	1 1 1	0.5		1.2	800	9	100		50				37
SS8550	TO-92 (92)	40	25	6	100	35	45 85 40	 300 	5 100 800	1 1 1	0.5		1.2	800	15	100		50				77

*Case style means available in EBC or ECB pinouts.

TEST CONDITIONS:

Note 1: $I_C/I_B = 20$
Note 2: $I_C/I_B = 40$
Note 3: $I_C/I_B = 50$
Note 4: $I_C = 1$ mA, f = 1 MHz
Note 5: $I_C = 100$ μA, f = 5 kHz
Note 6: $I_C = 1$ mA, f = 100 MHz
Note 7: $I_C = 200$ μA, f = 2 kHz

Consumers Series (Continued)

	HFE Bins												
	A	B	C	D	E	F	G	H	I	K	L	M	N
CS9011					39–60*	54–80	72–108	97–146	132–198				
CS9012				64–91*	78–112	96–135	118–166	144–202*					
CS9013				64–91*	78–112	96–135	118–166	144–202*					
CS9014	60–150	100–300	200–600										
CS9015	60–150	100–300	200–600										
CS9016				28–45*	39–60	54–80	72-108	97–146*					
CS9018				28–45*	39–60	54–80	72-108	97–146*					
ED1402	110–165*	150–225	202–318	290-450	410–810*								
ED1502	36–55*	48–75	66–100	84–127	105–210*								
ED1602	70–105*	90–140*	125–190	170–260	223–475*								
ED1702										106–150*	132–188	170–233	213–300*
ED1802										106–150*	132–188	170–233	213–300*

*Orders must contain at least two adjacent bins.

	HFE Bins						
	OR	YE	GR		B	C	D
SA1015	70–140*	120–240	200–400				
SC1815	70–140*	120–240	200–400				
SS8050					85–160	120–200	160–300*
SS8550					85–160	120–200	160–300*

*Orders must contain at least two adjacent bins.

Consumers Series (Continued)

	H_{FE} Bins											
	R	Q	P	K		G	H	I	J		X	Y
SA733	90–180	135–270	200–400	300–600								
SC945	90–180	135–270	200–400	300–600								
NA11						68–110*	100–160	140–240	200–350*		30–110	100–350
NA12						68–110*	100–160	140–240	200–350*		30–110	100–350
NA31						68–110	100–160	140–240*			30–110	100–350
NA32						68–110	100–160	140–240*			30–110	100–350
NA111							100–160	140–240	200–350			100–350
NA121							100–160	140–240	200–350			100–350

*Orders must contain at least two adjacent bins.

	H_{FE} Bins							
	E	F	G	H		R	S	T
NR421	30–50*	45–75	68-110	100–160*		20–50*	45–110	100-240*
NR431	30–50	45–75	68-110	100–160*		20–50*	45–110	100-240*

*Orders must contain at least two adjacent bins.

Section 9

Power Components

Section 9 Contents

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National Semiconductor

NPN Bipolar Power Transistors

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D42C1	TO-202 (56)		30	5	10*	40	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C2	TO-202 (56)		30	5	10*	40	40 20	120	0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C3	TO-202 (56)		30	5	10*	40	40 20		0.2 2	1 1	0.5		1.3	1	100	3		0.02	4P
D42C4	TO-202 (56)		45	5	10*	55	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C5	TO-202 (56)		45	5	100	55	40 20	120	0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C6	TO-202 (56)		45	5	10*	55	40 20		0.2 2	1 1	0.5		1.3	1	100	3		0.02	4P
D42C7	TO-202 (56)		60	5	100	75	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C8	TO-202 (56)		60	5	100	70	40 20	120	0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C9	TO-202 (56)		60	5	10*	70	40 20		0.2 2	1 1	0.5		1.3	1	100	3		0.02	4P
D42C10	TO-202 (56)		80	5	100	90	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D42C12	TO-202 (56)		80	5	10*	90	40		0.2	1	0.5		1.3	1	100	3		0.02	4P
D44C1	TO-220 (37)		30	5	10*	40	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C2	TO-220 (37)		30	5	10*	40	40 20	120	0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C3	TO-220 (37)		30	5	10*	40	40 20		0.2 2	1 1	0.5		1.3	1	100	3		0.02	4P

NPN Bipolar Power Transistors (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CEX}^* I_{CBO} (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D44C4	TO-220 (37)		45	5	10*	55	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C5	TO-220 (37)		45	5	100	55	40 20	120	0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C6	TO-220 (37)		45	5	10*	55	40 20		0.2 2	1 1	0.5		1.3	1	100	3		0.02	4P
D44C7	TO-220 (37)		60	5	100	75	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C8	TO-220 (37)		60	5	100	70	40 20	120	0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C9	TO-220 (37)		60	5	10*	70	40 20		0.2 2	1 1	0.5		1.3	1	100	3		0.02	4P
D44C10	TO-220 (37)		80	5	100	90	25 10		0.2 1	1 1	0.5		1.3	1	100	3		0.02	4P
D44C12	TO-220 (37)		80	5	10*	90	40		0.2	1	0.5		1.3	1	100	3		0.02	4P
D44H1	TO-220 (37)		30	5	10	30	35 20		2 4	1 1	1.0		1.5	8					4Q
D44H2	TO-220 (37)		30	5	10	30	60 40		2 4	1 1	1.0		1.5	8					4Q
D44H4	TO-220 (37)		45	5	10	45	35 20		2 4	1 1	1.0		1.5	8					4Q
D44H5	TO-220 (37)		45	5	10	45	60 40		2 4	1 1	1.0		1.5	8					4Q
D44H7	TO-220 (37)		60	5	10	60	35 20		2 4	1 1	1.0		1.5	8					4Q
D44H8	TO-220 (37)		60	5	10	60	60 40		2 4	1 1	1.0		1.5	8					4Q
D44H10	TO-220 (37)		80	5	10	80	35 20		2 4	1 1	1.0		1.5	8					4Q
D44H11	TO-220 (37)		80	5	10	80	60 40		2 4	1 1	1.0		1.5	8					4Q

National Semiconductor

PNP Bipolar Power Transistors

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}^* (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D43C1	TO-202		30	5	1 μA	1	10		1A	1	0.5		1.3	1A	30				5P
	(56)						25		200	1									
D43C2	TO-202		30	5	1 μA	30	20		1A	1	0.5		1.3	1A	30				5P
	(56)						40	120	200	1									
D43C3	TO-202		30	5	1 μA	30	20		1A	1	0.5		1.3	1A	30				5P
	(56)						40		200	1									
D43C4	TO-202		45	5	1 μA	45	10		1A	1	0.5		1.3	1A	30				5P
	(56)						25		200	1									
D43C5	TO-202		45	5	1 μA	45	20		1A	1	0.5		1.3	1A	30				5P
	(56)						40	120	200	1									
D43C6	TO-202		45	5	1 μA	45	20		2A	1	0.5		1.3	1A	30				5P
	(56)						40		200	1									
D43C7	TO-202		60	5	100	75	25		0.2	1	0.5		1.3	1	100	3		0.02	5P
	(56)						10		1	1									
D43C8	TO-202		60	5	100	70	40	120	0.2	1	0.5		1.3	1	100	3		0.02	5P
	(56)						20		1	1									
D43C9	TO-202		60	5	10*	70	40		0.2	1	0.5		1.3	1	100	3		0.02	5P
	(56)						20		2	1									
D43C10	TO-202		80	5	100	90	25		0.2	1	0.5		1.3	1	100	3		0.02	5P
	(56)						10		1	1									
D43C12	TO-202		80	5	10*	90	40		0.2	1	0.5		1.3	1	100	3		0.02	5P
D45C1	TO-220		30	5	10*	40	10		1	1	0.5		1.3	1	125	3		0.02	5P
	(37)						25		0.2	1									
D45C2	TO-220		30	5	10*	40	20		1	1	0.5		1.3	1	125	3		0.02	5P
	(37)						40	120	0.2	1									
D45C3	TO-220		30	5	10*	40	20		2	1	0.5		1.3	1	125	3		0.02	5P
	(37)						40		0.2	1									

PNP Bipolar Power Transistors (Continued)

Type No.	Case Style	V_{CBO} (V) Min	V_{CEO} (V) Min	V_{EBO} (V) Min	I_{CES}* (μA) Max	@ V_{CB} (V)	h_{FE} Min	h_{FE} Max	@ I_C (A)	& V_{CE} (V)	$V_{CE(SAT)}$ (V) Max	& $V_{BE(SAT)}$ (V) Min	$V_{BE(SAT)}$ (V) Max	@ I_C (A)	C_{ob} (pF) Max	f_T (MHz) Min	f_T (MHz) Max	@ I_C (A)	Process No.
D45C4	TO-220		45	5	10*	55	10		1	1	0.5		1.3	1	125	3		0.02	5P
	(37)						25		0.2	1									
D45C5	TO-220		45	5	10*	55	20		1	1	0.5		1.3	1	125	3		0.02	5P
	(37)						40	120	0.2	1									
D45C6	TO-220		45	5	10*	55	20		2	1	0.5		1.3	1	125	3		0.02	5P
	(37)						40		0.2	1									
D45C7	TO-220		60	5	10*	70	10		1	1	0.5		1.3	1	125	3		0.02	5P
	(37)						25		0.2	1									
D45C8	TO-220		60	5	10*	70	20		1	1	0.5		1.3	1	125	3		0.02	5P
	(37)						40	120	0.2	1									
D45C9	TO-220		60	5	10*		20		2	1	0.5		1.3	1	125	3		0.02	5P
	(37)						40		0.2	1									
D45C10	TO-220		80	5	10*	90	10		1	1	0.5		1.3	1	125	3		0.02	5P
D45C12	TO-220		80	5	10*	90					0.5		1.3	1	125	3		0.02	5P
	(37)						40		0.2	1									
D45H1	TO-220		30	5	10	30	20		4	1	1.0		1.5	8					5Q
	(37)						35		2	1									
D45H2	TO-220		30	5	10	30	40		4	1	1.0		1.5	8					5Q
	(37)						60		2	1									
D45H4	TO-220		45	5	10	45	20		4	1	1.0		1.5	8					5Q
	(37)						35		2	1									
D45H5	TO-220		45	5	10	45	40		4	1	1.0		1.5	8					5Q
	(37)						60		2	1									
D45H7	TO-220		60	5	10	60	20		4	1	1.0		1.5	8					5Q
	(37)						35		2	1									
D45H8	TO-220		60	5	10	60	40		4	1	1.0		1.5	8					5Q
	(37)						60		2	1									
D45H10	TO-220		80	5	10	80	20		4	1	1.0		1.5	8					5Q
	(37)						35		2	1									
D45H11	TO-220		80	5	10	80	40		4	1	1.0		1.5	8					5Q
	(37)						80		2	1									

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Single Rectifier per Package

Device No.	Case Style	V_{RRM} (V) Min	I_{RRM} (μA) Max @	V_R (V)	V_{FM} (V) Max @	I_F (A)	I_F Avg. A	t_{rr} (ns) Max	Test Cond.	Proc. Family
FRP805	TO-220AC (41)	50	10	50	0.95	8	8	35 50	(Note 1) (Note 2)	R4
FRP810	TO-220AC (41)	100	10	100	0.95	8	8	35 50	(Note 1) (Note 2)	R4
FRP815	TO-220AC (41)	150	10	150	0.95	8	8	35 50	(Note 1) (Note 2)	R4
FRP820	TO-220AC (41)	200	10	200	0.95	8	8	35 50	(Note 1) (Note 2)	R4
FRP840	TO-220AC (41)	400	10	400	1.5	8	8	75	(Note 2)	R6
FRP850	TO-220AC (41)	500	10	500	1.5	8	8	75	(Note 2)	R6
FRP860	TO-220AC (41)	600	10	600	1.5	8	8	75	(Note 2)	R6
FRP1005	TO-220AC (41)	50	5	50	1.0	10	10	35 50	(Note 1) (Note 3)	R4
FRP1010	TO-220AC (41)	100	5	100	1.0	10	10	35 50	(Note 1) (Note 3)	R4
FRP1015	TO-220AC (41)	150	5	150	1.0	10	10	35 50	(Note 1) (Note 3)	R4
FRP1020	TO-220AC (41)	200	5	200	1.0	10	10	35 50	(Note 1) (Note 3)	R4

TEST CONDITIONS:

Note 1: $I_F = 1.0A\ d_f/d_t = 50\ A/\mu s$

Note 2: $I_F = 8.0A\ d_f/d_t = 100\ A/\mu s$

Note 3: $I_F = 10A\ d_f/d_t = 100\ A/\mu s$

Note 4: $I_F = 16A\ d_f/d_t = 100\ A/\mu s$

Single Rectifier per Package (Continued)

Device No.	Case Style	V_{RRM} (V) Min	I_{RRM} (μA) Max @	V_R (V)	V_{FM} (V) Max @	I_F (A)	I_F Avg. A	t_{rr} (ns) Max	Test Cond.	Proc. Family
FRP1605	TO-220AC (41)	50	25	50	0.95	16	16	35 50	(Note 1) (Note 4)	R5
FRP1610	TO-220AC (41)	100	25	100	0.95	16	16	35 50	(Note 1) (Note 4)	R5
FRP1615	TO-220AC (41)	150	25	150	0.95	16	16	35 50	(Note 1) (Note 4)	R5
FRP1620	TO-220AC (41)	200	25	200	0.95	16	16	35 50	(Note 1) (Note 4)	R5

TEST CONDITIONS:

Note 1: $I_F = 1.0A\ d_f/d_t = 50\ A/\mu s$

Note 2: $I_F = 8.0A\ d_f/d_t = 100\ A/\mu s$

Note 3: $I_F = 10A\ d_f/d_t = 100\ A/\mu s$

Note 4: $I_F = 16A\ d_f/d_t = 100\ A/\mu s$

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Dual Rectifiers, Common Cathode

Device No.	Case Style	V_{RRM} (V) Min	I_{RRM} (μA) Max @	V_R (V)	V_F (V) Max @	I_F (A)	I_F Avg. A	t_{rr} (ns) Max	Test Cond.	Proc. Family
FRP1605CC	TO-220AB (38)	50	10	50	0.95	8	16	35 50	(Note 1) (Note 2)	R4
FRP1610CC	TO-220AB (38)	100	10	100	0.95	8	16	35 50	(Note 1) (Note 2)	R4
FRP1615CC	TO-220AB (38)	150	10	150	0.95	8	16	35 50	(Note 1) (Note 2)	R4
FRP1620CC	TO-220AB (38)	200	10	200	0.95	8	16	35 50	(Note 1) (Note 2)	R4
FRP1640CC	TO-220AB (38)	400	10	400	1.5	8	8	75	(Note 2)	R6
FRP1650CC	TO-220AB (38)	500	10	500	1.5	8	8	75	(Note 2)	R6
FRP1660CC	TO-220AB (38)	600	10	600	1.5	8	8	75	(Note 2)	R6
FRP2005CC	TO-220AB (38)	50	5	50	1.0	10	10	35 50	(Note 1) (Note 3)	R4
FRP2010CC	TO-220AB (38)	100	5	100	1.0	10	10	35 50	(Note 1) (Note 3)	R4
FRP2015CC	TO-220AB (38)	150	5	150	1.0	10	10	35 50	(Note 1) (Note 3)	R4
FRP2020CC	TO-220AB (38)	200	5	200	1.0	10	10	35 50	(Note 1) (Note 3)	R4

TEST CONDITIONS:

Note 1: $I_F = 1.0A\ d_f/d_t = 50\ A/\mu s$

Note 2: $I_F = 8.0A\ d_f/d_t = 100\ A/\mu s$

Note 3: $I_F = 10A\ d_f/d_t = 100\ A/\mu s$

Note 4: $I_F = 16A\ d_f/d_t = 100\ A/\mu s$

Dual Rectifiers, Common Cathode (Continued)

Device No.	Case Style	V_{RRM} (V) Min	I_{RRM} (µA) Max @	V_R (V)	V_F (V) Max @	I_F (A)	I_F Avg. A	t_{rr} (ns) Max	Test Cond.	Proc. Family
FRK3205CC	TO-247 (40)	50	25	50	0.95	16	32	35 50	(Note 1) (Note 4)	R5
FRK3210CC	TO-247 (40)	100	25	100	0.95	16	32	35 50	(Note 1) (Note 4)	R5
FRK3215CC	TO-247 (40)	150	25	150	0.95	16	32	35 50	(Note 1) (Note 4)	R5
FRK3220CC	TO-247 (40)	200	25	200	0.95	16	32	35 50	(Note 1) (Note 4)	R5

TEST CONDITIONS:

Note 1: $I_F = 1.0A\ d_f/d_t = 50\ A/\mu s$

Note 2: $I_F = 8.0A\ d_f/d_t = 100\ A/\mu s$

Note 3: $I_F = 10A\ d_f/d_t = 100\ A/\mu s$

Note 4: $I_F = 16A\ d_f/d_t = 100\ A/\mu s$

National Semiconductor

Power MOSFETs/COOLFETs™

Introduction

COOLFETs are power MOSFETs with a 20% lower ($R_{DS(on)}$ rating than the current industry standard. The 20% reduction in $R_{DS(on)}$ means a 12% increase in the current rating. Since all other electrical and thermal characteristics remain the same, COOLFETs can be used as either drop in replacements for standard IRF parts or in new designs.

As drop in replacements COOLFETs offer less power loss, cooler operation, higher efficiency and better reliability because the major contributor to power dissipation within a MOSFET is $I_D^2 R_{DS(on)}$.

In new designs, the circuit designer can take advantage of the higher current ratings on COOLFETs to design power supplies with more output power.

This data book contains a selection guide to the COOLFET family and specification sheets for each COOLFET device. Please note that COOLFETs are differentiated by the addition of a "CF" suffix to the standard nomenclature, e.g. IRF450CF, IRF840CF. Because all MOSFETs are susceptible to damage from electrostatic discharge, there is a note on ESD handling precautions for COOLFETs. Package outlines and a listing of sales offices and authorized distributors are also included in Section 12.

National Semiconductor

N-Channel Power MOSFETs

Type No.	Case Style	P_D (W) T_C = 25°C	V_{DSS} (V) Min	I_D @ T_C = 25°C (A)	I_{rD} @ T_C = 100°C (A)	$V_{GS(th)}$ (V) Min	$V_{GS(th)}$ (V) Max	@ I_D (mA)	$R_{DS(on)}$ (Ω) Max	@ I_D (A)	Q_g (nC) Max	C_{iss} (pF) Min	C_{iss} (pF) Max	C_{oss} (pF) Min	C_{oss} (pF) Max	C_{rss} (pF) Min	C_{rss} (pF) Max	Proc. No.
IRF510	TO-220 (37)	20	100	4	2.5	2	4	0.25	0.6	2	7.5		200		100		30	A1
IRF511	TO-220 (37)	20	60	4	2.5	2	4	0.25	0.6	2	7.5		200		100		30	A1
IRF512	TO-220 (37)	20	100	3.5	2	2	4	0.25	0.8	2	7.5		200		100		30	A1
IRF513	TO-220 (37)	20	60	3.5	2	2	4	0.25	0.8	2	7.5		200		100		30	A1
MTP4N08	TO-220 (37)	50	80	5	3.5	2	4.5	1	0.8	2	7.5		200		100		30	A1
MTP4N10	TO-220 (37)	50	100	5	3.5	2	4.5	1	0.8	2	7.5		200		100		30	A1
IRF610	TO-220 (37)	20	200	2.5	1.5	2	4	0.25	1.5	1	7.5		200		80		25	A2
IRF611	TO-220 (37)	20	150	2.5	1.5	2	4	0.25	1.5	1	7.5		200		80		25	A2
IRF612	TO-220 (37)	20	200	2.0	1.25	2	4	0.25	2.4	1	7.5		200		80		25	A2
IRF613	TO-220 (37)	20	150	2.0	1.25	2	4	0.25	2.4	1	7.5		200		80		25	A2
MTP2N18	TO-220 (37)	50	180	3.25	2.25	2	4.5	1	1.8	1	7.5		200		80		25	A2
MTP2N20	TO-220 (37)	50	200	3.25	2.25	2	4.5	1	1.8	1	7.5		200		80		25	A2
IRF710	TO-220 (37)	20	400	1.5	1	2	4	0.25	3.6	0.8	7.5		200		50		15	A3
IRF711	TO-220 (37)	20	350	1.5	1	2	4	0.25	3.6	0.8	7.5		200		50		15	A3

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V) Min	$V_{GS(th)}$ (V) Max	@ I_D (mA)	$R_{DS(on)}$ (Ω) Max	@ I_D (A)	Q_g (nC) Max	C_{iss} (pF) Min	C_{iss} (pF) Max	C_{oss} (pF) Min	C_{oss} (pF) Max	C_{rss} (pF) Min	C_{rss} (pF) Max	Proc. No.
IRF712	TO-220 (37)	20	400	1.3	0.9	2	4	0.25	5	0.8	7.5		200		50		15	A3
IRF713	TO-220 (37)	20	350	1.3	0.9	2	4	0.25	5	0.8	7.5		200		50		15	A3
MTP2N35	TO-220 (37)	50	350	2.25	1.4	2	4.5	1	5	1.0	7.5		200		50		15	A3
MTP2N40	TO-220 (37)	50	400	2.25	1.4	2	4.5	1	5	1.0	7.5		200		50		15	A3
FMP18N05	TO-220 (37)	75	50	18	13	2	4	0.25	0.1	10	20		850		400		150	B1
FMP18N06	TO-220 (37)	75	60	18	13	2	4	0.25	0.1	10	20		850		400		150	B1
FMP20N05	TO-220 (37)	75	50	20	14	2	4	0.25	0.085	10	20		850		400		150	B1
FMP20N06	TO-220 (37)	75	60	20	14	2	4	0.25	0.085	20	20		850		400		150	B1
IRF520	TO-220 (37)	40	100	8	5	2	4	0.25	0.3	4	15		600		400		100	B2
IRF521	TO-220 (37)	40	60	8	5	2	4	0.25	0.3	4	15		600		400		100	B2
IRF522	TO-220 (37)	40	100	7	4	2	4	0.25	0.4	4	15		600		400		100	B2
IRF523	TO-220 (37)	40	60	7	4	2	4	0.25	0.4	4	15		600		400		100	B2
MTP10N08	TO-220 (37)	75	80	10	6.4	2	4.5	1	0.33	5	15		600		400		100	B2
MTP10N10	TO-220 (37)	75	100	10	6.4	2	4.5	1	0.33	5	15		600		400		100	B2

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) T_C = 25°C	V_{DSS} (V) Min	I_D @ T_C = 25°C (A)	I_{rD} @ T_C = 100°C (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) @	I_D (A)	Q_g (nC)	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max		Max		Max	Min	Max	Min	Max	Min	Max	
IRF620	TO-220 (37)	40	200	5	3	2	4	0.25	0.8	2.5	15		600		300		80	B3
IRF621	TO-220 (37)	40	150	5	3	2	4	0.25	0.8	2.5	15		600		300		80	B3
IRF622	TO-220 (37)	40	200	4	2.5	2	4	0.25	1.2	2.5	15		600		300		80	B3
IRF623	TO-220 (37)	40	150	4	2.5	2	4	0.25	1.2	2.5	15		600		300		80	B3
MTP7N18	TO-220 (37)	75	180	7	4.5	2	4.5	1	0.7	3.5	15		600		300		80	B3
MTP7N20	TO-220 (37)	75	200	7	4.5	2	4.5	1	0.7	3.5	15		600		300		80	B3
IRF720	TO-220 (37)	40	400	3	2	2	4	0.25	1.8	1.5	15		500		100		40	B4
IRF721	TO-220 (37)	40	350	3	2	2	4	0.25	1.8	1.5	15		500		100		40	B4
IRF722	TO-220 (37)	40	400	2.5	1.5	2	4	0.25	2.5	1.5	15		500		100		40	B4
IRF723	TO-220 (37)	40	350	2.5	1.5	2	4	0.25	2.5	1.5	15		500		100		40	B4
MTP3N35	TO-220 (37)	75	350	3	2	2	4.5	1	3.3	1.5	15		500		100		40	B4
MTP3N40	TO-220 (37)	75	400	3	2	2	4.5	1	3.3	1.5	15		500		100		40	B4
IRF820	TO-220 (37)	40	500	2.5	1.5	2	4	0.25	3	1	15		400		100		40	B5
IRF821	TO-220 (37)	40	450	2.5	1.5	2	4	0.25	3	1	15		400		100		40	B5
IRF822	TO-220 (37)	40	500	2.0	1.0	2	4	0.25	4	1	15		400		100		40	B5
IRF823	TO-220 (37)	40	450	2.0	1.0	2	4	0.25	4	1	15		400		100		40	B5
MTP2N45	TO-220 (37)	75	450	3.0	2.0	2	4.5	1	4	1	15		400		100		40	B5
MTP2N50	TO-220 (37)	75	500	3.0	2.0	2	4.5	1	4	1	15		400		100		40	B5

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) Max @	I_D (A)	Q_g (nC) Max	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max					Min	Max	Min	Max	Min	Max	
2N6755	TO-204AA (42)	75	60	12	8	2	4	1	0.25	8	30 (Note 1)	350	800	150	500	50	150	C1
2N6756	TO-204AA (42)	75	100	14	9	2	4	1	0.18	9	30 (Note 1)	350	800	150	500	50	150	C1
IRF130	TO-204AA (42)	75	100	14	9	2	4	0.25	0.18	8	30		800		500		150	C1
IRF131	TO-204AA (42)	75	60	14	9	2	4	0.25	0.18	8	30		800		500		150	C1
IRF132	TO-204AA (42)	75	100	12	8	2	4	0.25	0.25	8	30		800		500		150	C1
IRF133	TO-204AA (42)	75	60	12	8	2	4	0.25	0.25	8	30		800		500		150	C1
IRF530	TO-220 (37)	75	100	14	9	2	4	0.25	0.18	8	30		800		500		150	C1
IRF531	TO-220 (37)	75	60	14	9	2	4	0.25	0.18	8	30		800		500		150	C1
IRF532	TO-220 (37)	75	100	12	8	2	4	0.25	0.25	8	30		800		500		150	C1
IRF533	TO-220 (37)	75	60	12	8	2	4	0.25	0.25	8	30		800		500		150	C1
MTP20N08	TO-220 (37)	100	80	20	11.5	2	4.5	1	0.15	10	30		800		500		150	C1
MTP20N10	TO-220 (37)	100	100	20	11.5	2	4.5	1	0.15	10	30		800		500		150	C1
2N6757	TO-204AA (42)	75	150	8	5	2	4	1	0.6	5	30 (Note 1)	350	800	100	450	40	150	C2
2N6758	TO-204AA (42)	75	200	9	6	2	4	1	0.4	6	30 (Note 1)	350	800	100	450	40	150	C2
IRF230	TO-204AA (42)	75	200	9	6	2	4	0.25	0.4	5	30		800		450		150	C2
IRF231	TO-204AA (42)	75	150	9	6	2	4	0.25	0.4	5	30		800		450		150	C2

Note 1: Non-JEDEC registered value.

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) T_C = 25°C	V_{DSS} (V) Min	I_D @ T_C = 25°C (A)	I_{rD} @ T_C = 100°C (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) Max @	I_D (A)	Q_g (nC) Max	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max					Min	Max	Min	Max	Min	Max	
IRF232	TO-204AA (42)	75	200	8	5	2	4	0.25	0.5	5	30		800		450		150	C2
IRF233	TO-204AA (42)	75	150	8	5	2	4	0.25	0.5	5	30		800		450		150	C2
IRF630	TO-220 (37)	75	200	9	6	2	4	0.25	0.4	5	30		800		450		150	C2
IRF631	TO-220 (37)	75	150	9	6	2	4	0.25	0.4	5	30		800		450		150	C2
IRF632	TO-220 (37)	75	200	8	5	2	4	0.25	0.5	5	30		800		450		150	C2
IRF633	TO-220 (37)	75	150	8	5	2	4	0.25	0.5	5	30		800		450		150	C2
MTP12N18	TO-220 (37)	100	180	12	8.5	2	4.5	1	0.35	6	30		800		450		150	C2
MTP12N20	TO-220 (37)	100	200	12	8.5	2	4.5	1	0.35	6	30		800		450		150	C2
2N6759	TO-204AA (42)	75	350	4.5	3	2	4	1	1.5	3.5	30 (Note 1)	350	800	50	300	20	80	C3
2N6760	TO-204AA (42)	75	400	5.5	3.5	2	4	1	1	3	30 (Note 1)	350	800	50	300	20	80	C3
IRF330	TO-204AA (42)	75	400	5.5	3.8	2	4	0.25	1	3	30		900		300		80	C3
IRF331	TO-204AA (42)	75	350	5.5	3.8	2	4	0.25	1	3	30		900		300		80	C3
IRF332	TO-204AA (42)	75	400	4.5	3.0	2	4	0.25	1.5	3	30		900		300		80	C3
IRF333	TO-204AA (42)	75	350	4.5	3.0	2	4	0.25	1.5	3	30		900		300		80	C3
IRF730	TO-220 (37)	75	400	5.5	3.8	2	4	0.25	1	3	30		900		300		80	C3
IRF731	TO-220 (37)	75	350	5.5	3.8	2	4	0.25	1	3	30		900		300		80	C3

Note 1: Non-JEDEC registered value.

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V) Min	$V_{GS(th)}$ (V) Max	@ I_D (mA)	$R_{DS(on)}$ (Ω) Max	@ I_D (A)	Q_g (nC) Max	C_{iss} (pF) Min	C_{iss} (pF) Max	C_{oss} (pF) Min	C_{oss} (pF) Max	C_{rss} (pF) Min	C_{rss} (pF) Max	Proc. No.
IRF732	TO-220 (37)	75	400	4.5	3.0	2	4	0.25	1.5	3	30		900		300		80	C3
IRF733	TO-220 (37)	75	350	4.5	3.0	2	4	0.25	1.5	3	30		900		300		80	C3
MTP5N35	TO-220 (37)	75	350	5	3.8	2	4.5	1.0	1	2.5	30		1200		300		80	C3
MTP5N40	TO-220 (37)	75	400	5	3.8	2	4.5	1.0	1	2.5	30		1200		300		80	C3
2N6761	TO-204AA (42)	75	450	4	2.5	2	4	1	2	2.5	30 (Note 1)	350	800	25	200	15	60	C4
2N6762	TO-204AA (42)	75	500	4.5	3	2	4	1	1.5	3	30 (Note 1)	350	800	25	200	15	60	C4
IRF430	TO-204AA (42)	75	500	4.5	3.0	2	4	0.25	1.5	2.5	30		800		200		60	C4
IRF431	TO-204AA (42)	75	450	4.5	3.0	2	4	0.25	1.5	2.5	30		800		200		60	C4
IRF432	TO-204AA (42)	75	500	4	2.7	2	4	0.25	2.0	2.5	30		800		200		60	C4
IRF433	TO-204AA (42)	75	450	4	2.7	2	4	0.25	2.0	2.5	30		800		200		60	C4
IRF830	TO-220 (37)	75	500	4.5	3.0	2	4	0.25	1.5	2.5	30		800		200		60	C4
IRF831	TO-220 (37)	75	450	4.5	3.0	2	4	0.25	1.5	2.5	30		800		200		60	C4
IRF832	TO-220 (37)	75	500	4	2.7	2	4	0.25	2.0	2.5	30		800		200		60	C4
IRF833	TO-220 (37)	75	450	4	2.7	2	4	0.25	2.0	2.5	30		800		200		60	C4

Note 1: Non-JEDEC registered value.

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{RD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V) Min	$V_{GS(th)}$ (V) Max	I_D @ (mA)	$R_{DS(on)}$ (Ω) Max @	I_D (A)	Q_g (nC) Max	C_{iss} (pF) Min	C_{iss} (pF) Max	C_{oss} (pF) Min	C_{oss} (pF) Max	C_{rss} (pF) Min	C_{rss} (pF) Max	Proc. No.
MTP4N45	TO-220 (35)	75	450	4	3.0	2	4.5	1.0	1.5	2	30		1200		300		80	C4
MTP4N50	TO-220 (35)	75	500	4	3.0	2	4.5	1.0	1.5	2	30		1200		300		80	C4
IRF140	TO-204AA (42)	125	100	27	17	2	4	0.25	0.085	15	60		1600		800		300	E1
IRFP140	TO-3P (40)	150	100	29	19	2	4	0.25	0.085	15	60		1600		800		300	E1
IRF141	TO-204AA (42)	125	60	27	17	2	4	0.25	0.085	15	60		1600		800		300	E1
IRFP141	TO-3P (40)	150	60	29	19	2	4	0.25	0.085	15	60		1600		800		300	E1
IRF142	TO-204AA (42)	125	100	24	15	2	4	0.25	0.11	15	60		1600		800		300	E1
IRF143	TO-204AA (42)	125	60	24	15	2	4	0.25	0.11	15	60		1600		800		300	E1
IRF540	TO-220 (37)	125	100	27	17	2	4	0.25	0.085	15	60		1600		800		300	E1
IRF541	TO-220 (37)	125	60	27	17	2	4	0.25	0.085	15	60		1600		800		300	E1
IRF542	TO-220 (37)	125	100	24	15	2	4	0.25	0.11	15	60		1600		800		300	E1
IRF543	TO-220 (37)	125	60	24	15	2	4	0.25	0.11	15	60		1600		800		300	E1
IRF240	TO-204AA (42)	125	200	18	11	2	4	0.25	0.18	10	60		1600		750		300	E2
IRFP240	TO-3P (40)	150	200	20	13	2	4	0.25	0.18	10	60		1600		750		300	E2
IRF241	TO-204AA (42)	125	150	18	11	2	4	0.25	0.18	10	60		1600		750		300	E2
IRFP241	TO-3P (40)	150	150	20	13	2	4	0.25	0.18	10	60		1600		750		300	E2
IRF242	TO-204AA (42)	125	200	16	10	2	4	0.25	0.22	10	60		1600		750		300	E2
IRF243	TO-204AA (42)	125	150	16	10	2	4	0.25	0.22	10	60		1600		750		300	E2

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V) Min	$V_{GS(th)}$ (V) Max	I_D @ (mA)	$R_{DS(on)}$ (Ω) Max @	I_D (A)	Q_g (nC) Max	C_{iss} (pF) Min	C_{iss} (pF) Max	C_{oss} (pF) Min	C_{oss} (pF) Max	C_{rss} (pF) Min	C_{rss} (pF) Max	Proc. No.
IRF640	TO-220 (37)	125	200	18	11	2	4	0.25	0.18	10	60		1600		750		300	E2
IRF641	TO-220 (37)	125	150	18	11	2	4	0.25	0.18	10	60		1600		750		300	E2
IRF642	TO-220 (37)	125	200	16	10	2	4	0.25	0.22	10	60		1600		750		300	E2
IRF643	TO-220 (37)	125	150	16	10	2	4	0.25	0.22	10	60		1600		750		300	E2
IRF340	TO-204AA (42)	125	400	10	6.7	2	4	0.25	0.55	5	60		1600		450		150	E3
IRFP340	TO-3P (40)	150	400	12	7.5	2	4	0.25	0.55	5	60		1600		450		150	E3
IRF341	TO-204AA (42)	125	350	10	6.7	2	4	0.25	0.55	5	60		1600		450		150	E3
IRFP341	TO-3P (40)	150	350	12	7.5	2	4	0.25	0.55	5	60		1600		450		150	E3
IRF342	TO-204AA (42)	125	400	8	5.5	2	4	0.25	0.8	5	60		1600		450		150	E3
IRF343	TO-204AA (42)	125	350	8	5.5	2	4	0.25	0.8	5	60		1600		450		150	E3
IRF740	TO-220 (37)	125	400	10	6.7	2	4	0.25	0.55	5	60		1600		450		150	E3
IRF741	TO-220 (37)	125	350	10	6.7	2	4	0.25	0.55	5	60		1600		450		150	E3
IRF742	TO-220 (37)	125	400	8	5.5	2	4	0.25	0.8	5	60		1600		450		150	E3
IRF743	TO-220 (37)	125	350	8	5.5	2	4	0.25	0.8	5	60		1600		450		150	E3
IRF440	TO-204AA (42)	125	500	8	5.3	2	4	0.25	0.85	4	60		1600		350		150	E4
IRFP440	TO-3P (40)	150	500	9.5	6.0	2	4	0.25	0.85	4	60		1600		350		150	E4
IRF441	TO-204AA (42)	125	450	8	5.3	2	4	0.25	0.85	4	60		1600		350		150	E4

N-Channel Power MOSFETs (Continued)

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V)		I_D	$R_{DS(on)}$ (Ω)	I_D	Q_g (nC)	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max	@ (mA)	Max @	(A)	Max	Min	Max	Min	Max	Min	Max	
IRFP441	TO-3P (40)	150	450	9.5	6.0	2	4	0.25	0.85	4	60		1600		350		150	E4
IRF442	TO-204AA (42)	125	500	7	4.8	2	4	0.25	1.1	4	60		1600		350		150	E4
IRF443	TO-204AA (42)	125	450	7	4.8	2	4	0.25	1.1	4	60		1600		350		150	E4
IRF840	TO-220 (37)	125	500	8	5.3	2	4	0.25	0.85	4	60		1600		350		150	E4
IRF841	TO-220 (37)	125	450	8	5.3	2	4	0.25	0.85	4	60		1600		350		150	E4
IRF842	TO-220 (37)	125	500	7	4.8	2	4	0.25	1.1	4	60		1600		350		150	E4
IRF843	TO-220 (37)	125	450	7	4.8	2	4	0.25	1.1	4	60		1600		350		150	E4
2N6763	TO-204AE (43)	150	60	31	20	2	4	1	0.08	20	120 (Note 1)	1000	3000	500	1500	150	500	F1
2N6764	TO-204AE (43)	150	100	38	24	2	4	1	0.055	24	120 (Note 1)	1000	3000	500	1500	150	500	F1
IRF150	TO-204AE (43)	150	100	40	23	2	4	0.25	0.055	20	120		3000		1500		500	F1
IRFP150	TO-3P (40)	175	100	40	25	2	4	0.25	0.055	20	120		3000		1500		500	F1
IRF151	TO-204AE (43)	150	60	40	23	2	4	0.25	0.055	20	120		3000		1500		500	F1
IRFP151	TO-3P (40)	175	60	40	25	2	4	0.25	0.055	20	120		3000		1500		500	F1
IRF152	TO-204AE (43)	150	100	33	19	2	4	0.25	0.08	20	120		3000		1500		500	F1
IRF153	TO-204AE (43)	150	60	33	19	2	4	0.25	0.08	20	120		3000		1500		500	F1
2N6765	TO-204AE (43)	150	150	25	16	2	4	1	0.12	16	120 (Note 1)	1000	3000	450	1200	150	500	F2
2N6766	TO-204AE (43)	150	200	30	19	2	4	1	0.085	19	120 (Note 1)	1000	3000	450	1200	150	500	F2
IRF250	TO-204AE (43)	150	200	30	18.5	2	4	0.25	0.085	16	120		3000		1200		500	F2
IRFP250	TO-3P (40)	175	200	32	20	2	4	0.25	0.085	16	120		3000		1200		500	F2
IRF251	TO-204AE (43)	150	150	30	18.5	2	4	0.25	0.085	16	120		3000		1200		500	F2

Note 1: Non-JEDEC registered value.

N-Channel Power MOSFETs

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) Max @	I_D (A)	Q_g (nC) Max	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max					Min	Max	Min	Max	Min	Max	
IRFP251	TO-3P (40)	175	150	32	20	2	4	0.25	0.085	16	120		3000		1200		500	F2
IRF252	TO-204AE (43)	150	200	25	15	2	4	0.25	0.12	16	120		3000		1200		500	F2
IRF253	TO-204AE (43)	150	150	25	15	2	4	0.25	0.12	16	120		3000		1200		500	F2
2N6767	TO-204AA (42)	150	350	12	7.75	2	4	1	0.4	7.75	120 (Note 1)	1000	3000	200	600	50	200	F3
2N6768	TO-204AA (42)	150	400	14	9	2	4	1	0.3	9	120 (Note 1)	1000	3000	200	600	50	200	F3
IRF350	TO-204AA (42)	150	400	15	10	2	4	0.25	0.3	8	120		3000		600		200	F3
IRFP350	TO-3P (40)	175	400	17	11	2	4	0.25	0.3	8	120		3000		600		200	F3
IRF351	TO-204AA (42)	150	350	15	10	2	4	0.25	0.3	8	120		3000		600		200	F3
IRFP351	TO-3P (40)	175	350	17	11	2	4	0.25	0.3	8	120		3000		600		200	F3
IRF352	TO-204AA (42)	150	400	13	8.5	2	4	0.25	0.4	8	120		3000		600		200	F3
IRF353	TO-204AA (42)	150	350	13	8.5	2	4	0.25	0.4	8	120		3000		600		200	F3
2N6769	TO-204AA (42)	150	450	11	7	2	4	1	0.5	7	120 (Note 1)	1000	3000	200	600	50	200	F4
2N6770	TO-204AA (42)	150	500	12	7.75	2	4	1	0.4	7.75	120 (Note 1)	1000	3000	200	600	50	200	F4
IRF450	TO-204AA (42)	150	500	13	8.5	2	4	0.25	0.4	7	120		3000		600		200	F4
IRFP450	TO-3P (40)	175	500	15	9.5	2	4	0.25	0.4	7	120		3000		600		200	F4
IRF451	TO-204AA (42)	150	450	13	8.5	2	4	0.25	0.4	7	120		3000		600		200	F4
IRFP451	TO-3P (40)	175	450	15	9.5	2	4	0.25	0.4	7	120		3000		600		200	F4
IRF452	TO-204AA (42)	150	500	12	7.5	2	4	0.25	0.5	7	120		3000		600		200	F4
IRF453	TO-204AA (42)	150	450	12	7.5	2	4	0.25	0.5	7	120		3000		600		200	F4

Note 1: Non-JEDEC registered value.

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COOLFETs™

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) @	I_D (A)	Q_g (nC)	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max		Max		Max	Min	Max	Min	Max	Min	Max	
IRF520CF	TO-220 (37)	40	100	9.1	5.8	2	4	0.25	0.24	4	15		600		400		100	B2
IRF620CF	TO-220 (37)	40	200	5.6	3.5	2	4	0.25	0.64	2.5	15		600		300		80	B3
IRF720CF	TO-220 (37)	40	400	3.35	2.15	2	4	0.25	1.44	1.5	15		500		100		40	B4
IRF820CF	TO-220 (37)	40	500	2.8	1.75	2	4	0.25	2.4	1	15		400		100		40	B5
IRF530CF	TO-220 (37)	75	100	16	10	2	4	0.25	0.144	8	30		800		500		150	C1
IRF630CF	TO-220 (37)	75	200	10	8.5	2	4	0.25	0.32	5	30		800		450		150	C2
IRF730CF	TO-220 (37)	75	400	6.2	3.9	2	4	0.25	0.8	3	30		900		300		80	C3
IRF830CF	TO-200 (37)	75	500	5	3.2	2	4	0.25	1.2	2.5	30		800		200		60	C4
IRFP140CF	TO-3P (40)	150	100	33	21	2	4	0.25	0.068	15	60		1600		800		300	E1
IRFP141CF	TO-3P (40)	150	60	33	21	2	4	0.25	0.068	15	60		1600		800		300	E1
IRF540CF	TO-220 (37)	125	100	30	19	2	4	0.25	0.068	15	60		1600		800		300	E1

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COOLFETs™

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V) Min	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) Max @	I_D (A)	Q_g (nC) Max	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
						Min	Max					Min	Max	Min	Max	Min	Max	
IRFP240CF	TO-3P (40)	150	200	23	14	2	4	0.25	0.144	10	60		1600		750		300	E1
IRFP241CF	TO-3P (40)	150	150	23	14	2	4	0.25	0.144	10	60		1600		750		300	E1
IRF640CF	TO-220 (40)	125	200	20	13	2	4	0.25	0.144	10	60		1600		750		300	E2
IRFP340CF	TO-3P (40)	150	400	13	8	2	4	0.25	0.44	5	60		1600		450		150	E3
IRFP341CF	TO-3P (40)	150	350	13	8	2	4	0.25	0.44	5	60		1600		450		150	E3
IRF740CF	TO-220 (37)	125	400	11	7	2	4	0.25	0.44	5	60		1600		450		150	E3
IRF840CF	TO-200 (37)	125	500	8.9	5.6	2	4	0.25	0.68	4	60		1600		350		150	E4
IRFP440CF	TO-3P (40)	150	500	10.5	6.5	2	4	0.25	0.68	4	60		1600		350		150	E4
IRFP441CF	TO-3P (40)	150	450	10.5	6.5	2	4	0.25	0.68	4	60		1600		350		150	E4
IRF150CF	TO-204AE (40)	150	100	44	28	2	4	0.25	0.044	20	120		3000		1500		500	F1
IRFP150CF	TO-3P (40)	175	100	44.5	28	2	4	0.25	0.044	20	120		3000		1500		500	F1
IRFP151CF	TO-3P (40)	175	60	44.5	28	2	4	0.25	0.044	20	120		3000		1500		500	F1
IRF250CF	TO-204AE (40)	150	200	33	21	2	4	0.25	0.068	16	120		3000		1200		500	F2
IRFP250CF	TO-3P (40)	175	200	36	23	2	4	0.25	0.068	16	120		3000		1200		500	F2
IRFP251CF	TO-3P (40)	175	150	36	23	2	4	0.25	0.068	16	120		3000		1200		500	F2

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COOLFETs™

Type No.	Case Style	P_D (W) $T_C = 25°C$	V_{DSS} (V)	I_D @ $T_C = 25°C$ (A)	I_{rD} @ $T_C = 100°C$ (A)	$V_{GS(th)}$ (V)		I_D @ (mA)	$R_{DS(on)}$ (Ω) @	I_D (A)	Q_g (nC)	C_{iss} (pF)		C_{oss} (pF)		C_{rss} (pF)		Proc. No.
			Min			Min	Max		Max		Max	Min	Max	Min	Max	Min	Max	
IRF350CF	TO-204AE (42)	150	400	16.75	10.6	2	4	0.25	0.24	8	120		3000		600		200	F3
IRFP350CF	TO-3P (43)	175	400	19	12	2	4	0.25	0.24	8	120		3000		600		200	F3
IRFP351CF	TO-3P (43)	175	350	19	12	2	4	0.25	0.24	8	120		3000		600		200	F3
IRF450CF	TO-204AE (42)	150	500	14.5	9.2	2	4	0.25	0.32	7	120		3000		600		200	F4
IRFP450CF	TO-3P (43)	175	500	16.5	10.5	2	4	0.25	0.32	7	120		3000		600		200	F4
IRFP451CF	TO-3P (43)	175	450	16.5	10.5	2	4	0.25	0.32	7	120		3000		600		200	F4

Section 10
Transistor Datasheets

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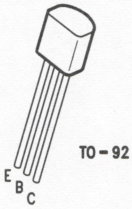
PN100 MMBT100



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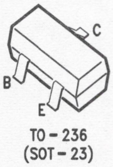


TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

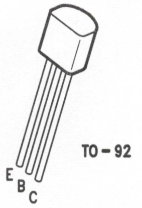
Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
BV_{CBO}	$I_C = 10\ \mu A$	75			V
BV_{CEO}	$I_C = 1\ mA$, (Note 1)	45			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 60V$			50	nA
I_{CES}	$V_{CE} = 40V$			50	nA
I_{EBO}	$V_{EB} = 4V$			50	nA
ON CHARACTERISTICS					
h_{FE}	$I_C = 100\ \mu A, V_{CE} = 1V$	80			
h_{FE}	$I_C = 10\ mA, V_{CE} = 1V$	100		450	
h_{FE}	$I_C = 100\ mA, V_{CE} = 1V$, (Note 1)	100			
h_{FE}	$I_C = 150\ mA, V_{CE} = 5V$, (Note 1)	100		350	
$V_{CE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.2	V
$V_{BE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.85	V
$V_{CE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			0.4	V
$V_{BE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			1.0	V
SMALL-SIGNAL CHARACTERISTICS					
C_{ob}	$V_{CB} = 5V, f = 1\ MHz$			4.5	pF
f_T	$V_{CE} = 20V, I_C = 20\ mA$	250			MHz
t_s	$I_C = 10\ mA, I_{B1} = I_{B2} = 1\ mA$		275		ns
t_{OFF}	$I_C = 150\ mA, I_{B1} = I_{B2} = 15\ mA$		225		ns
NF	$I_C = 100\ \mu A, V_{CE} = 5V, R_G = 2\ k\Omega, f = 1\ kHz$			5.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 10.

National Semiconductor

PN100A MMBT100A



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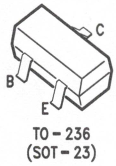


TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

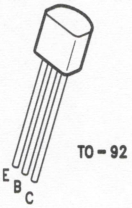
Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
BV_{CBO}	$I_C = 10\ \mu A$	75			V
BV_{CEO}	$I_C = 1\ mA$, (Note 1)	45			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 60V$			50	nA
I_{CES}	$V_{CE} = 40V$			50	nA
I_{EBO}	$V_{EB} = 4V$			50	nA
ON CHARACTERISTICS					
h_{FE}	$I_C = 100\ \mu A, V_{CE} = 1V$	240			
h_{FE}	$I_C = 10\ mA, V_{CE} = 1V$	300		600	
h_{FE}	$I_C = 100\ mA, V_{CE} = 1V$, (Note 1)	100			
h_{FE}	$I_C = 150\ mA, V_{CE} = 5V$, (Note 1)	100			
$V_{CE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.2	V
$V_{BE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.85	V
$V_{CE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			0.4	V
$V_{BE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			1.0	V
SMALL-SIGNAL CHARACTERISTICS					
C_{ob}	$V_{CB} = 5V, f = 1\ MHz$			4.5	pF
f_T	$V_{CE} = 20V, I_C = 20\ mA$	250			MHz
NF	$I_C = 100\ \mu A, V_{CE} = 5V, R_G = 2\ k\Omega, f = 1\ kHz$		1.5	4.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 10.

National Semiconductor

PN101



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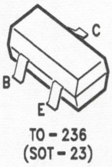
MMBT101



TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
BV_{CBO}	$I_C = 10\ \mu A$	100		V
BV_{CEO}	$I_C = 1\ mA$, (Note 1)	65		V
BV_{EBO}	$I_E = 10\ \mu A$	6		V
I_{CBO}	$V_{CB} = 60V$		50	nA
I_{CES}	$V_{CE} = 50V$		50	nA
I_{EBO}	$V_{EB} = 4V$		50	nA
ON CHARACTERISTICS				
h_{FE}	$I_C = 100\ \mu A, V_{CE} = 1V$	60		
h_{FE}	$I_C = 10\ mA, V_{CE} = 1V$	75	375	
h_{FE}	$I_C = 100\ mA, V_{CE} = 5V$, (Note 1)	50		
$V_{CE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$		0.2	V
$V_{BE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$		0.85	V
$V_{CE(sat)}$	$I_C = 100\ mA, I_B = 10\ mA$, (Note 1)		0.35	V
$V_{BE(sat)}$	$I_C = 100\ mA, I_B = 10\ mA$, (Note 1)		0.95	V
SMALL-SIGNAL CHARACTERISTICS				
C_{ob}	$V_{CB} = 5V, f = 1\ MHz$		4.0	pF
f_T	$V_{CE} = 10V, I_C = 10\ mA$	125		MHz
NF	$I_C = 100\ \mu A, V_{CE} = 5V, R_G = 2\ k\Omega, f = 1\ kHz$		8.0	dB

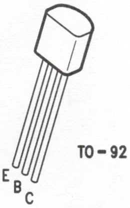
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 11.

National Semiconductor

PN200

MMBT200



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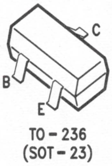

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PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

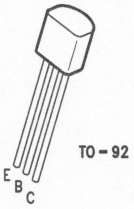
Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
BV_{CBO}	$I_C = 10\ \mu A$	60			V
BV_{CEO}	$I_C = 1\ mA$, (Note 1)	45			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 50V$			50	nA
I_{CES}	$V_{CE} = 40V$			50	nA
I_{EBO}	$V_{EB} = 4V$			50	nA
ON CHARACTERISTICS					
h_{FE}	$I_C = 100\ \mu A, V_{CE} = 1V$	80			
h_{FE}	$I_C = 10\ mA, V_{CE} = 1V$	100		450	
h_{FE}	$I_C = 100\ mA, V_{CE} = 1V$, (Note 1)	100			
h_{FE}	$I_C = 150\ mA, V_{CE} = 5V$, (Note 1)	100		350	
$V_{CE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.2	V
$V_{BE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.85	V
$V_{CE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			0.4	V
$V_{BE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			1.0	V
SMALL-SIGNAL CHARACTERISTICS					
C_{ob}	$V_{CB} = 5V, f = 1\ MHz$			6.0	pF
f_T	$V_{CE} = 20V, I_C = 20\ mA$	250			MHz
t_s	$I_C = 10\ mA, I_{B1} = I_{B2} = 1\ mA$		275		ns
t_{OFF}	$I_C = 150\ mA, I_{B1} = I_{B2} = 15\ mA$		225		ns
NF	$I_C = 100\ \mu A, V_{CE} = 5V, R_G = 2\ k\Omega, f = 1\ kHz$			5.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 68.

National Semiconductor

PN200A MMBT200A



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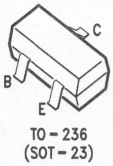


TL/G/10100-5

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

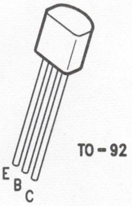
Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
BV_{CBO}	$I_C = 10\ \mu A$	60			V
BV_{CEO}	$I_C = 1\ mA$, (Note 1)	45			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 50V$			50	nA
I_{CES}	$V_{CE} = 40V$			50	nA
I_{EBO}	$V_{EB} = 4V$			50	nA
ON CHARACTERISTICS					
h_{FE}	$I_C = 100\ \mu A, V_{CE} = 1V$	240			
h_{FE}	$I_C = 10\ mA, V_{CE} = 1V$	300		600	
h_{FE}	$I_C = 100\ mA, V_{CE} = 1V$, (Note 1)	100			
h_{FE}	$I_C = 150\ mA, V_{CE} = 5V$, (Note 1)	100			
$V_{CE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.2	V
$V_{BE(sat)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.85	V
$V_{CE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			0.4	V
$V_{BE(sat)}$	$I_C = 200\ mA, I_B = 20\ mA$, (Note 1)			1.0	V
SMALL-SIGNAL CHARACTERISTICS					
C_{ob}	$V_{CB} = 5V, f = 1\ MHz$			6.0	pF
f_T	$V_{CE} = 20V, I_C = 20\ mA$	250			MHz
NF	$I_C = 100\ \mu A, V_{CE} = 5V, R_G = 2\ k\Omega, f = 1\ kHz$		1.5	4.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 68.

National Semiconductor

PN201 MMBT201



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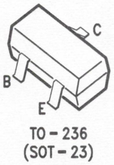


TL/G/10100-5

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

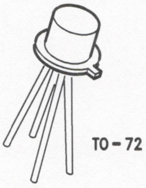
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
BV_{CBO}	$I_C = 10\ \mu A$	80		V
BV_{CEO}	$I_C = 1$ mA, (Note 1)	65		V
BV_{EBO}	$I_E = 10\ \mu A$	6		V
I_{CBO}	$V_{CB} = 60V$		50	nA
I_{CES}	$V_{CE} = 50V$		50	nA
I_{EBO}	$V_{EB} = 4V$		50	nA
ON CHARACTERISTICS				
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 1V$	60		
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	75	375	
h_{FE}	$I_C = 100$ mA, $V_{CE} = 5V$, (Note 1)	50		
$V_{CE(sat)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.2	V
$V_{BE(sat)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.85	V
$V_{CE(sat)}$	$I_C = 100$ mA, $I_B = 10$ mA, (Note 1)		0.4	V
$V_{BE(sat)}$	$I_C = 100$ mA, $I_B = 10$ mA, (Note 1)		1.0	V
SMALL-SIGNAL CHARACTERISTICS				
C_{ob}	$V_{CB} = 5V$, f = 1 MHz		6.0	pF
f_T	$V_{CE} = 10V$, $I_C = 10$ mA	100		MHz
NF	$I_C = 100\ \mu A$, $V_{CE} = 5V$, $R_G = 2\ k\Omega$, f = 1 kHz		8.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 69.

National Semiconductor

2N918 PN918 MMBT918



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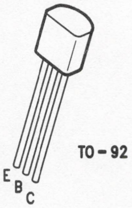

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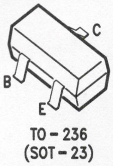


TL/G/10100-5

NPN RF Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage, (Note 2) ($I_C = 3.0$ mAdc, $I_B = 0$)	15		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 1.0\ \mu$Adc, $I_E = 0$)	30		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	3.0		Vdc
I_{CBO}	Collector-Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)		0.010 1.0	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	20		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		0.4	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product, (Note 1) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	600		MHz
C_{obo}	Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz) ($V_{CB} = 0$, $I_E = 0$, f = 140 kHz)		1.7 3.0	pF
C_{ibo}	Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		2.0	pF
NF	Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, $R_G = 400\Omega$, f = 60 MHz)		6.0	dB

NPN RF Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter	Min	Max	Units
FUNCTIONAL TEST				
G_{pe}	Amplifier Power Gain ($V_{CB} = 12$ Vdc, $I_C = 6.0$ mAdc, f = 200 MHz)	15		dB
P_o	Power Output ($V_{CB} = 15$ Vdc, $I_C = 8.0$ mAdc, f = 500 MHz)	30		mW
η	Collector Efficiency ($V_{CB} = 15$ Vdc, $I_C = 8.0$ mAdc, f = 500 MHz)	25		%

Note 1: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

Note 2: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 3: For characteristics curves, see Process 43.

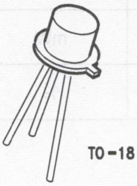
National Semiconductor

2N2222 2N2222A

PN2222 PN2222A

MMBT2222 MMBT2222A

MPQ2222*



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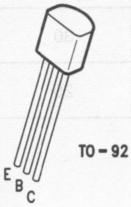

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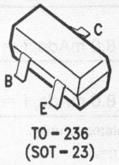

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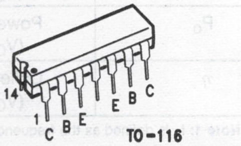


TL/G/10100-7

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage (Note 1) ($I_C = 10$ mA, $I_B = 0$)	2222	30		V
		2222A	40		
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$, $I_E = 0$)	2222	60		V
		2222A	75		
$V_{(BR)EBO}$	Emitter Base Breakdown Voltage ($I_E = 10\ \mu A$, $I_C = 0$)	2222	5.0		V
		2222A	6.0		
I_{CEX}	Collector Cutoff Current ($V_{CE} = 60V$, $V_{EB(OFF)} = 3.0V$)	2222A		10	nA
I_{CBO}	Collector Cutoff Current ($V_{CB} = 50V$, $I_E = 0$)	2222		0.01	μA
	($V_{CB} = 60V$, $I_E = 0$)	2222A		0.01	
	($V_{CB} = 50V$, $I_E = 0$, $T_A = 150°C$)	222		10	
	($V_{CB} = 60V$, $I_E = 0$, $T_A = 150°C$)	2222A		10	
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 3.0V$, $I_C = 0$)	2222A		10	nA
I_{BL}	Base Cutoff Current ($V_{CE} = 60V$, $V_{EB(OFF)} = 3.0$)	2222A		20	nA
ON CHARACTERISTICS					
h_{FE}	DC Current Gain ($I_C = 0.1$ mA, $V_{CE} = 10V$)		35		
	($I_C = 1.0$ mA, $V_{CE} = 10V$)		50		
	($I_C = 10$ mA, $V_{CE} = 10V$)		75		
	($I_C = 10$ mA, $V_{CE} = 10V$, $T_A = -55°C$)		35		
	($I_C = 150$ mA, $V_{CE} = 10V$) (Note 1)		100	300	
	($I_C = 150$ mA, $V_{CE} = 1.0V$) (Note 1)		50		
	($I_C = 500$ mA, $V_{CE} = 10V$) (Note 1)	2222	30		
		2222A	40		

Note 1: Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

*16-SOIC version also available. Contact factory.

NPN General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter			Min	Max	Units
ON CHARACTERISTICS (Continued)						
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)					
	($I_C = 150$ mA, $I_B = 15$ mA)		2222		0.4	V
			2222A		0.3	
	($I_C = 500$ mA, $I_B = 50$ mA)		2222		1.6	
			2222A		1.0	
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)					
	($I_C = 150$ mA, $I_B = 15$ mA)		2222	0.6	1.3	V
			2222A	0.6	1.2	
	($I_C = 500$ mA, $I_B = 50$ mA)		2222		2.6	
			2222A		2.0	
SMALL-SIGNAL CHARACTERISTICS						
f_T	Current Gain—Bandwidth Product (Note 3) ($I_C = 20$ mA, $V_{CE} = 20V$, $f = 100$ MHz)		2222	250		MHz
			2222A	300		
C_{obo}	Output Capacitance (Note 3) ($V_{CB} = 10V$, $I_E = 0$, $f = 100$ kHz)				8.0	pF
C_{ibo}	Input Capacitance (Note 3) ($V_{EB} = 0.5V$, $I_C = 0$, $f = 100$ kHz)		2222		30	pF
			2222A		25	
$rb'C_C$	Collector Base Time Constant ($I_E = 20$ mA, $V_{CB} = 20V$, $f = 31.8$ MHz)		2222A		150	ps
NF	Noise Figure ($I_C = 100$ μA, $V_{CE} = 10V$, $R_S = 1.0$ kΩ, $f = 1.0$ kHz)		2222A		4.0	dB
$Re(h_{ie})$	Real Part of Common-Emitter High Frequency Input Impedance ($I_C = 20$ mA, $V_{CE} = 20V$, $f = 300$ MHz)				60	Ω
SWITCHING CHARACTERISTICS						
t_D	Delay Time	($V_{CC} = 30V$, $V_{BE(OFF)} = 0.5V$, $I_C = 150$ mA, $I_{B1} = 15$ mA)	except MPQ2222		10	ns
t_R	Rise Time				25	ns
t_S	Storage Time	($V_{CC} = 30V$, $I_C = 150$ mA, $I_{B1} = I_{B2} = 15$ mA	except MPQ2222		225	ns
t_F	Fall Time				60	ns

Note 1: Pulse Test: Pulse Width < 300 μs, Duty Cycle ≤ 2.0%.

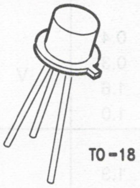
Note 2: For characteristics curves, see Process 19.

Note 3: f_T is defined as the frequency at which $|h_{fe}|$ extrapotates to unity.

Note 4: 2N also available in JAN/TX/V series.

National Semiconductor

2N2369



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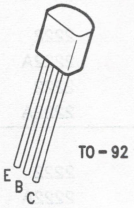
PN2369



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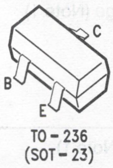
MMBT2369



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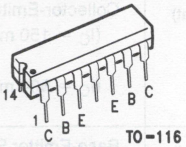
MPQ2369



TL/G/10100-7

NPN Switching Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 2) ($I_C = 10$ mAdc, $I_B = 0$)	15			Vdc
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu$Adc, $V_{BE} = 0$)	40			Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	40			Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	4.5			Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 125°C$)			0.4 30	μAdc
ON CHARACTERISTICS					
h_{FE}	DC Current Gain, (Note 1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	40 20 20		120	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)			0.25	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	0.70		0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
C_{obo}	Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)			4.0	pF
h_{fe}	Small-Signal Current Gain ($I_C = 10$ mAdc, $V_C = 10$ Vdc, f = 100 MHz)	5.0			

NPN Switching Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter		Min	Typ	Max	Units
SWITCHING CHARACTERISTICS						
t_s	Storage Time ($I_{B1} = I_{B2} = I_C = 10$ mAdc) *(Figure 3)*	*Except MPQ2369		5.0	13*	ns
t_{on}	Turn-On Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc) *(Figure 1)*	*Except MPQ2369		8.0	12*	ns
t_{off}	Turn-Off Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.5$ mAdc) *(Figure 2)*	*Except MPQ2369		10	18*	ns

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 21.

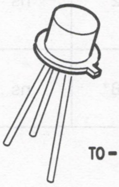
National Semiconductor

2N2907 2N2907A

PN2907 PN2907A

MMBT2907 MMBT2907A

MPQ2907*



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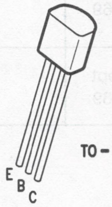

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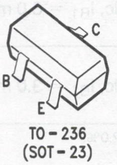

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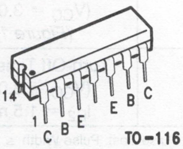


TL/G/10100-7

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 0$)	2907 2907A	40 60		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		60		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		5.0		Vdc
I_{CEX}	Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0.5$ Vdc)			50	nAdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)	2907 2907A 2907 2907A		0.020 0.010 20 10	μAdc
I_B	Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 0.5$ Vdc)			50	nAdc

*16-SOIC version also available. Contact factory.

PNP General Purpose Amplifier (Continued)

Electrical Characteristics T_A = 25°C unless otherwise noted (Continued)

Symbol	Parameter		Min	Max	Units
ON CHARACTERISTICS					
h_{FE}	DC Current Gain				
	(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2907	35		
		2907A	75		
	(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2907	50		
		2907A	100		
	(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2907	75		
		2907A	100		
	(I_C = 150 mAdc, V_{CE} = 10 Vdc), (Note 1)		100	300	
	(I_C = 500 mAdc, V_{CE} = 10 Vdc), (Note 1)	2907	30		
		2907A	50		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage, (Note 1)				
	(I_C = 150 mAdc, I_B = 15 mAdc)			0.4	Vdc
	(I_C = 500 mAdc, I_B = 50 mAdc)			1.6	
$V_{BE(sat)}$	Base-Emitter Saturation Voltage				
	(I_C = 150 mAdc, I_B = 15 mAdc), (Note 1)			1.3	Vdc
	(I_C = 500 mAdc, I_B = 50 mAdc)			2.6	
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		200		MHz
C_{obo}	Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			8.0	pF
C_{ibo}	Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)			30	pF
SWITCHING CHARACTERISTICS					
t_{on}	Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) Except MPQ2907		45	ns
t_d	Delay Time			10	ns
t_r	Rise Time			40	ns
t_{off}	Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) Except MPQ2907		100	ns
t_s	Storage Time			80	ns
t_f	Fall Time			30	ns

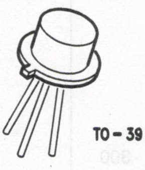
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 63.

Note 3: 2N also available in JAN/TX/V series.

National Semiconductor

2N3019 TN3019



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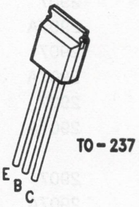


TL/G/10100-8

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 30$ mAdc, $I_B = 0$)	80		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	140		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	7.0		Vdc
I_{CBO}	Collector Cutoff Current			
	($V_{CB} = 90$ Vdc, $I_E = 0$)		0.01	μAdc
	($V_{CB} = 90$ Vdc, $I_E = 0$, $T_A = 150°C$)		10	μAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		0.010	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain			
	($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	50		
	($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	90		
	($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	100	300	
	($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc, $T_C = -55°C$)	40		
	($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	50		
	($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc)	15		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage			
	($I_C = 150$ mAdc, $I_B = 15$ mAdc)		0.2	Vdc
	($I_C = 500$ mAdc, $I_B = 50$ mAdc)		1.5	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		1.1	Vdc

NPN General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	100	400	MHz
C_{obo}	Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		12	pF
C_{ibo}	Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		60	pF
h_{fe}	Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	80	400	
$rb'C_c$	Collector Base Time Constant ($I_E = 10$ mAdc, $V_{CB} = 10$ Vdc, f = 4.0 MHz) 2N3019, 2N3020		400	ps
NF	Noise Figure ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ kΩ, f = 1.0 kHz)		4	dB

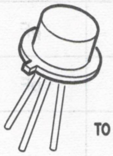
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

Note 2: For characteristics curves, see Process 12.

Note 3: 2N also available in JAN/TX/V series.

National Semiconductor

2N3467 TN3467 MPQ3467



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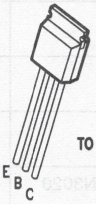

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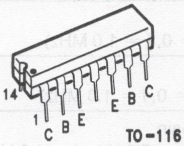
TL/G/10100-8



TO-116

TL/G/10100-7

PNP Switching Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 0$)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	40		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	5.0		Vdc
I_{BEV}	Base Cutoff Current ($V_{CE} = -30$ Vdc, $V_{BE} = 3.0$ Vdc)		120	nAdc
I_{CEX}	Collector Cutoff Current ($V_{CE} = -30$ Vdc, $V_{BE} = 3.0$ Vdc)		100	nAdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 100°C$)		0.010 15	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain, (Note 1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)	40 40 40	120	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage, (Note 1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		0.3 0.5 1.0	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage, (Note 1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)	0.8	1.0 1.2 1.6	Vdc

PNP Switching Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

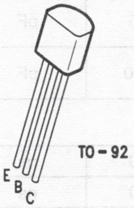
Symbol	Parameter		Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		175		MHz
C_{obo}	Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)			25	pF
C_{ibo}	Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)			100	pF
SWITCHING CHARACTERISTICS					
t_d	Delay Time	($I_C = 500$ mA, $I_{B1} = 50$ mA, $V_{BE} = 2.0V$, $V_{CC} = 30V$)		10	ns
t_r	Rise Time			30	ns
t_s	Storage Time	$I_C = 500$ mA, $I_{B1} = I_{B2} = 50$ mA, $V_{CC} = 30V$)		60	ns
t_f	Fall Time			30	ns

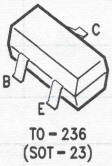
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 70.

National Semiconductor

PN3646 MMBT3646





NPN Switching Transistor

Electrical Characteristics T_A = 25°C unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	40		Vdc
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage, (Note 1) (I_C = 10 mAdc, I_B = 0)	15		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	40		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	5.0		Vdc
I_{CES}	Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = 65°C)		0.5 3.0	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 0.5 Vdc) (I_C = 300 mA, V_{CE} = 1.0 Vdc)	30 25 15	120	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 30 mA, I_B = 3.0 mA, T_A = 65°C)		0.2 0.28 0.5 0.3	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	0.75	0.95 1.2 1.7	Vdc

NPN Switching Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

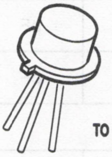
Symbol	Parameter		Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current Gain—Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		350		MHz
C_{obo}	Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)			5.0	pF
C_{ibo}	Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)				pF
SWITCHING CHARACTERISTICS					
t_{on}	Turn-On Time	($V_{CC} = 10$ Vdc, $V_{BE(off)} = 3.0$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc) *(Figure 1)*		18	ns
t_d	Delay Time			10	ns
t_r	Rise Time			15	ns
t_{off}	Turn-Off Time	($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = I_{B2} = 30$ mAdc) *(Figure 1)*		28	ns
t_f	Fall Time			15	ns
t_s	Storage Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc) *(Figure 2)*			18	ns

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 22.

National Semiconductor

2N3725 TN3725 MPQ3725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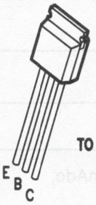

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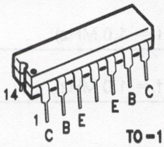


TO-116

TL/G/10100-7

NPN Switching Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 0$)	50		Vdc
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu$Adc, $V_{BE} = 0$)	80		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	80		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	6.0		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 100°C$)		1.7 120	μAdc
I_{CES}	Collector Cutoff Current ($V_{CE} = 80$ Vdc, $V_{EB} = 0$)		10	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain			
	($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	30		
	($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	60	150	
	($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	30		
	($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc)	40		
	($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)	35		
	($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	20		
	($I_C = 800$ mA, $V_{CE} = 2.0$V)	20		
	($I_C = 1.0$ Adc, $V_{CE} = 5.0$V)	25		

NPN Switching Transistor (Continued)

Electrical Characteristics T_A = 25°C unless otherwise noted (Continued)

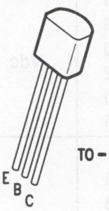
Symbol	Parameter		Min	Max	Units
ON CHARACTERISTICS (Note 1) (Continued)					
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mA) (I_C = 800 mAdc, I_B = 80 mA) (I_C = 1.0 mAdc, I_B = 100 mA			0.25 0.26 0.40 0.52 0.80 0.95	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 800 mAdc, I_B = 80 mAdc) (I_C = 1.0 mAdc, I_B = 100 mAdc)			0.76 0.86 1.1 1.1 1.5 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		300		MHz
C_{obo}	Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)			10	pF
C_{ibo}	Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)			55	pF
SWITCHING CHARACTERISTICS					
t_d	Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) *(Figures 8, 10)*, except MPQ3725		10	ns
t_r	Rise Time			30	ns
t_{on}	Turn-On Time			35	ns
		MPQ3725		40	ns
t_s	Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) *(Figures 9, 10)*, except MPQ3725		50	ns
t_f	Fall Time			25	ns
t_{off}	Turn-On Time			60	ns
		MPQ3725		75	ns

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

Note 2: For characteristics curves, see Process 25.

National Semiconductor

2N3904 MMBT3904 MPQ3904*



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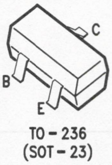

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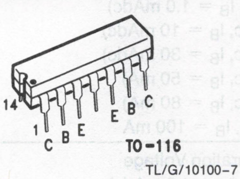


TL/G/10100-7

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 0$)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	60		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	6.0		Vdc
I_{BL}	Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		50	nAdc
I_{CEX}	Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		50	nAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain, (Note 1) ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	 40 70 100 60 30	 300	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		 0.2 0.3	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	 0.65	 0.85 0.95	Vdc

*16-SOIC version also available. Contact factory.

NPN General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

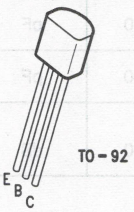
Symbol	Parameter			Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS						
f_T	Current Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)			300		MHz
C_{obo}	Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)				4.0	pF
C_{ibo}	Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)				8.0	pF
NF	Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 10 Hz to 15.7 kHz)		2N3904 MMBT3904		5.0	dB
SWITCHING CHARACTERISTICS						
t_d	Delay Time	($V_{CC} = 3.0$ Vdc, $V_{BE} = 0.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc)	2N3904 MMBT3904		35	ns
t_r	Rise Time				35	ns
t_s	Storage Time	($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)	2N3904 MMBT3904		200	ns
t_f	Fall Time				50	ns

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 23.

National Semiconductor

2N3906



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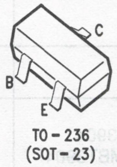
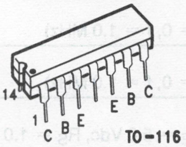
MMBT3906



TL/G/10100-5

MPQ3906*



TL/G/10100-7

PNP General Purpose Amplifier

Electrical Characteristics T_A = 25°C unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) (I_C = 1.0 mAdc, I_B = 0)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	40		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	5.0		Vdc
I_{BL}	Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		50	nAdc
I_{CEX}	Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		50	nAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain, (Note 1)			
	(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	60		
	(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	80		
	(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	100	300	
	(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	60		
	(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	30		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage			Vdc
	(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.25	
	(I_C = 50 mAdc, I_B = 5.0 mAdc)		0.4	
$V_{BE(sat)}$	Base-Emitter Saturation Voltage			Vdc
	(I_C = 10 mAdc, I_B = 1.0 mAdc)	0.65	0.85	
	(I_C = 50 mAdc, I_B = 5.0 mAdc)		0.95	

*16-SOIC version also available. Contact factory.

PNP General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

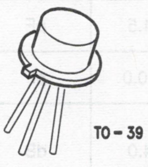
Symbol	Parameter		Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		250		MHz
C_{obo}	Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 MHz)			4.5	pF
C_{ibo}	Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)			10.0	pF
NF	Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 10 Hz to 15.7 kHz)	2N3906 MMBT3906		4.0	dB
SWITCHING CHARACTERISTICS					
t_d	Delay Time	($V_{CC} = 3.0$ Vdc, $V_{BE} = 0.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc) 2N3906 MMBT3906		35	ns
t_r	Rise Time			35	ns
t_s	Storage Time	($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc) 2N3906 MMBT3906		225	ns
t_f	Fall Time			75	ns

Note 1: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 66.

National Semiconductor

2N4033 TN4033



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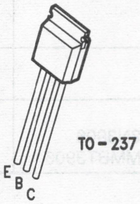


TL/G/10100-8

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 10$ mA)	80		V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10$ μA)	80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μA)	5.0		V
I_{CBO}	Collector-Cutoff Current ($V_{CB} = 60V$) ($V_{CB} = 60V$, $T_A = 150°C$)		50 50	nA μA
I_{EBO}	Emitter-Cutoff Current ($V_{EB} = 5.0V$)		10	μA
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain ($I_C = 100$ mA, $V_{CE} = 5.0V$, @ $-55°C$) ($I_C = 100$ μA, $V_{CE} = 5.0V$) ($I_C = 100$ mA, $V_{CE} = 5.0V$) ($I_C = 500$ mA, $V_{CE} = 5.0V$) ($I_C = 1.0A$, $V_{CE} = 5.0V$)	40 75 100 70 25	300	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA)		0.15 0.50	V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA)		0.9	V
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 500$ mA, $V_{CE} = 0.5V$)		1.1	V

PNP General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

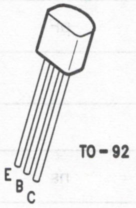
Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
C_{obo}	Output Capacitance ($V_{CE} = 10V$, $f = 1.0$ MHz)		20	pF
C_{ibo}	Input Capacitance ($V_{EB} = 0.5V$, $f = 1.0$ MHz)		110	pF
h_{fe}	Small Signal Current Gain ($I_C = 50$ mA, $V_{CE} = 10V$, $f = 100$ MHz)	1.0	4.0	
SWITCHING CHARACTERISTICS				
t_s	Storage Time ($I_C = 500$ mA, $I_{B1} = I_{B2} = 50$ mA)		350	ns
t_{on}	Turn-On Time ($I_C = 500$ mA, $I_{B1} = 50$ mA)		100	ns
t_f	Fall Time ($I_C = 500$ mA, $I_{B1} = I_{B2} = 50$ mA)		50	ns

Note 1: Pulse Width = 300 μs, Duty Cycle 1.0%.

Note 2: For characteristics curves, see Process 67.

National Semiconductor

PN4258 MMBT4258



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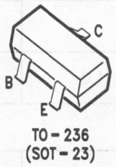


TL/G/10100-5

PNP Switching Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 100\ \mu Adc, V_{BE} = 0$)	12		Vdc
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage, (Note 1) ($I_C = 3.0\ mAdc, I_B = 0$)	12		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc, I_E = 0$)	12		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc, I_C = 0$)	4.5		Vdc
I_{CES}	Collector Cutoff Current ($V_{CE} = 6.0\ Vdc, V_{BE} = 0$) ($V_{CE} = 6.0\ Vdc, V_{BE} = 0, T_A = 65°C$)		0.01 5.0	µAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain ($I_C = 1.0\ mAdc, V_{CE} = 0.5\ Vdc$) ($I_C = 10\ mAdc, V_{CE} = 3.0\ Vdc$) ($I_C = 50\ mAdc, V_{CE} = 1.0\ Vdc$)	15 30 30	120	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 10\ mAdc, I_B = 1.0\ mAdc$) ($I_C = 50\ mAdc, I_B = 5.0\ mAdc$)		0.15 0.5	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 10\ mAdc, I_B = 1.0\ mAdc$) ($I_C = 50\ mAdc, I_B = 5.0\ mAdc$)	0.75	0.95 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product, (Note 2) ($I_C = 10\ mAdc, V_{CE} = 5.0\ Vdc, f = 100\ MHz$) ($I_C = 10\ mAdc, V_{CE} = 10\ Vdc, f = 100\ MHz$)	700		MHz
C_{ibo}	Input Capacitance ($V_{BE} = 0.5\ Vdc, I_C = 0, f = 1.0\ MHz$)		3.5	pF
C_{cb}	Collector-Base Capacitance ($V_{CB} = 5.0\ Vdc, I_E = 0, f = 1.0\ MHz$)		3.0	pF

PNP Switching Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter		Min	Max	Units
SWITCHING CHARACTERISTICS					
t_{on}	Turn-On Time	($V_{CC} = 1.5$ Vdc, $V_{BE(off)} = 0V$, $I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc)		15	ns
t_d	Delay Time			10	ns
t_r	Rise Time	($V_{CC} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)		15	ns
t_{off}	Turn-Off Time			20	ns
t_s	Storage Time			20	ns
t_f	Fall Time			10	ns
t_s	Storage Time ($I_C \approx 10$ mAdc, $I_{B1} \approx 10$ mAdc, $I_{B2} \approx 10$ mAdc)			20	ns

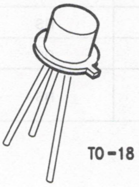
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: f_T is defined as the frequency at which $|h_{FE}|$ extrapolates unity.

Note 3: For characteristics curves, see Process 65.

National Semiconductor

2N4391 2N4392 2N4393 PN4391 PN4392 PN4393 MMBF4391 MMBF4392 MMBF4393



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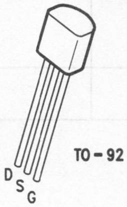
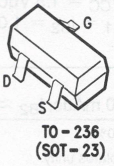


TL/G/10100-2



TL/G/10100-6

General Purpose N-Channel JFET Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Typ	Max	Units
OFF CHARACTERISTICS						
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc, V_{DS} = 0$)		30			Vdc
I_{GSS}	Gate Reverse Current ($V_{GS} = 15\ Vdc, V_{DS} = 0$) ($V_{GS} = 15\ Vdc, V_{DS} = 0, T_A = 100°C$)				1.0 0.2	nAdc μAdc
$I_{D(off)}$	Drain-Cutoff Current ($V_{DS} = 15\ Vdc, V_{GS} = 12\ Vdc$) ($V_{DS} = 15\ Vdc, V_{GS} = 12\ Vdc, T_A = 100°C$)				1.0 0.1	nAdc μAdc
V_{GS}	Gate Source Voltage ($V_{DS} = 15\ Vdc, I_D = 10\ nAdc$)	4391 4392 4393	4.0 2.0 0.5		10 5.0 3.0	Vdc
ON CHARACTERISTICS						
I_{DSS}	Zero-Gate-Voltage Drain Current, (Note 1) ($V_{DS} = 15\ Vdc, V_{GS} = 0$)	4391 4392 4393	60 25 5.0		130 75 30	mAdc
$V_{DS(on)}$	Drain-Source On-Voltage ($I_D = 12\ mAdc, V_{GS} = 0$) ($I_D = 6.0\ mAdc, V_{GS} = 0$) ($I_D = 3.0\ mAdc, V_{GS} = 0$)	4391 4392 4393			0.4 0.4 0.4	Vdc
$r_{DS(on)}$	Static Drain-Source On Resistance ($I_D = 1.0\ mAdc, V_{GS} = 0$)	4391 4392 4393			30 60 100	Ω

General Purpose N-Channel JFET Transistor (Continued)

Electrical Characteristics T_A = 25°C unless otherwise noted (Continued)

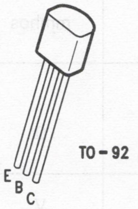
Symbol	Parameter		Min	Typ	Max	Units
SMALL-SIGNAL CHARACTERISTICS						
$\lvert y_{fs} \rvert$	Forward Transfer Admittance					mmhos
	(V_{DS} = 15 Vdc, I_D = 60 mAdc, f = 1.0 kHz)	4391		20		
	(V_{DS} = 15 Vdc, I_D = 25 mAdc, f = 1.0 kHz)	4392		17		
	(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	4393		12		
$r_{DS(on)}$	Drain-Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)					Ω
		4391			30	
		4392			60	
		4393			100	
C_{iss}	Input Capacitance (V_{GS} = 15 Vdc, V_{DS} = 0, f = 1.0 MHz)			8.0	14	V
C_{rss}	Reverse Transfer Capacitance					pF
	(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)			2.5	3.5	
	(V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)			3.2		
SWITCHING CHARACTERISTICS						
t_r	Rise Time (See *Figure 2*)					ns
	($I_{D(on)}$ = 12 mAdc)	4391		1.2	5.0	
	($I_{D(on)}$ = 6.0 mAdc)	4392		2.0	5.0	
	($I_{D(on)}$ = 3.0 mAdc)	4393		2.5	5.0	
t_f	Fall Time (See *Figure 4*)					ns
	($V_{GS(off)}$ = 12 Vdc)	4391		7.0	15	
	($V_{GS(off)}$ = 7.0 Vdc)	4392		15	20	
	($V_{GS(off)}$ = 5.0 Vdc)	4393		29	35	
t_{on}	Turn-On Time (See *Figures 1* and *2*)					ns
	($I_{D(on)}$ = 12 mAdc)	4391		3.0	15	
	($I_{D(on)}$ = 6.0 mAdc)	4392		4.0	15	
	($I_{D(on)}$ = 3.0 mAdc)	4393		6.5	15	
t_{off}	Turn-Off Time (See *Figures 3* and *4*)					ns
	($V_{GS(off)}$ = 12 Vdc)	4391		10	20	
	($V_{GS(off)}$ = 7.0 Vdc)	4392		20	35	
	($V_{GS(off)}$ = 5.0 Vdc)	4393		37	55	

Note 1: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

Note 2: For characteristics curves, see Process 51.

National Semiconductor

2N4401



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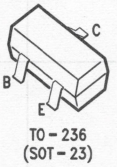
MMBT4401



TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	60		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	6.0		Vdc
I_L	Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{EB} = 0.4$ Vdc)		0.1	μAdc
I_{CEX}	Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{EB} = 0.4$ Vdc)		0.1	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain			
	($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	20		
	($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	40		
	($I_C = 10$ Adc, $V_{CE} = 1.0$ Vdc)	80		
	($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)	100	300	
	($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)	40		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage			Vdc
	($I_C = 150$ mAdc, $I_B = 15$ mAdc)		0.4	
	($I_C = 500$ mAdc, $I_B = 50$ mAdc)		0.75	
$V_{BE(sat)}$	Base-Emitter Saturation Voltage			Vdc
	($I_C = 150$ mAdc, $I_B = 15$ mAdc)	0.75	0.95	
	($I_C = 500$ mAdc, $I_B = 50$ mAdc)		1.2	

NPN General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

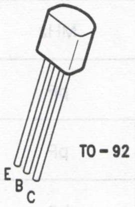
Symbol	Parameter		Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current Gain—Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		250		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)			6.5	pF
C_{eb}	Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)			30	pF
h_{ie}	Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		1.0	15	kΩ
h_{re}	Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		0.1	8.0	$\times 10^{-4}$
h_{fe}	Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		40	500	
h_{oe}	Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		1.0	30	μmhos
SWITCHING CHARACTERISTICS					
t_d	Delay Time	($V_{CC} = 30$ Vdc, $V_{EB} = 0.2$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)		15	ns
t_r	Rise Time			20	ns
t_s	Storage Time	($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)		225	ns
t_f	Fall Time			30	ns

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 13.

National Semiconductor

2N4403 MMBT4403



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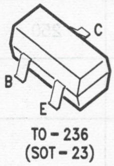


TL/G/10100-5

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	40		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	5.0		Vdc
I_L	Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)		0.1	μAdc
I_{CEX}	Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)		0.1	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 2.0$ Vdc), (Note 1) ($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc), (Note 1)	 30 60 100 100 20	 300 	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage, (Note 1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		 0.4 0.75	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage, (Note 1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	 0.75 	 0.95 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	200		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		8.5	pF
C_{eb}	Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		30	pF

PNP General Purpose Amplifier (Continued)

Electrical Characteristics T_A = 25°C unless otherwise noted (Continued)

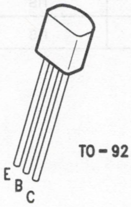
Symbol	Parameter		Min	Max	Units
SWITCHING CHARACTERISTICS					
t_d	Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		15	ns
t_r	Rise Time			20	ns
t_s	Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		225	ns
t_f	Fall Time			30	ns

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 63.

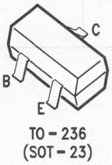
National
Semiconductor

2N5086
2N5087



TL/G/10100-1

MMBT5086
MMBT5087



TL/G/10100-5

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)		50		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		50		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 35$ Vdc, $I_E = 0$)			10 50	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)			50	nAdc
ON CHARACTERISTICS					
h_{FE}	DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	2N5086	150	500	
		2N5087	250	800	
	($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N5086	150		
		2N5087	250		
	($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc), (Note 1)	2N5086	150		
		2N5087	250		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)			0.3	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)			0.85	Vdc

PNP General Purpose Amplifier (Continued)

Electrical Characteristics T_A = 25°C unless otherwise noted (Continued)

Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product (I_C = 50 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	40		MHz
C_{cb}	Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		4.0	pF
h_{fe}	Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) 2N5086	150	600	
	2N5087	250	900	
NF	Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz) 2N5086		3.0	dB
	2N5087		2.0	
	(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 kΩ, f = 1.0 kHz) 2N5086		3.0	
	2N5087		2.0	

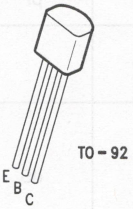
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 62.

National Semiconductor

2N5088
2N5089

MMBT5088
MMBT5089



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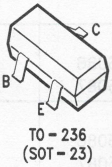


TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	2N5088 2N5089	30 25		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	2N5088 2N5089	35 30		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$)	2N5088 2N5089		50 50	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB(off)} = 3.0$ Vdc, $I_C = 0$) ($V_{EB(off)} = 4.5$ Vdc, $I_C = 0$)			50 100	nAdc
ON CHARACTERISTICS					
h_{FE}	DC Current Gain ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N5088 2N5089	300 400	900 1200	
	($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N5088 2N5089	350 450		
	($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc), (Note 1)	2N5088 2N5089	300 400		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 1.0$ mAdc)			0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)			0.8	Vdc

NPN General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

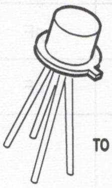
Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product ($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	50		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		4.0	pF
C_{eb}	Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		10	pF
h_{fe}	Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) 2N5088 2N5089	350 450	1400 1800	
NF	Noise Figure ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10\ k\Omega$, 2N5088 f = 10 Hz to 15.7 kHz) 2N5089		3.0 2.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 07.

National Semiconductor

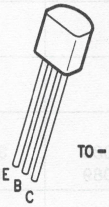
2N5179



TO-72

TL/G/10100-12

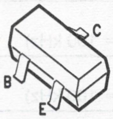
PN5179



TO-92

TL/G/10100-1

MMBT5179



TO-236
(SOT-23)

TL/G/10100-5

NPN RF Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage, (Note 2) ($I_C = 30$ mAdc, $I_B = 0$)	12		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 0.001$ mAdc, $I_E = 0$)	20		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)	2.5		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)		0.02 1.0	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	25	250	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		0.4	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product, (Note 1) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)	900	2000	MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 to 1.0 MHz)		1.0	pF
h_{fe}	Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 kHz)	25	300	
$rb'C_C$	Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 6.0$ Vdc, f = 31.9 MHz)	3.0	14	ps
NF	Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50\Omega$, f = 200 MHz)		4.5	dB

NPN RF Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter	Min	Max	Units
FUNCTIONAL TEST				
G_{pe}	Common-Emitter Amplifier Power Gain *(Figure 1)* ($V_{CE} = 6.0$ Vdc, $I_C = 5.0$ mAdc, f = 200 MHz)	15		dB
P_{out}	Power Output ($V_{CB} = 10$ Vdc, $I_E = 12$ mAdc, f $\geq$ 500 MHz)	20		mW

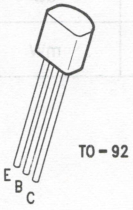
Note 1: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

Note 2: Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

Note 3: For characteristics curves, see Process 40.

National Semiconductor

2N5401 MMBT5401



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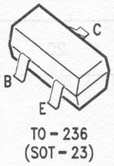


TL/G/10100-5

PNP General Purpose Amplifier

Electrical Characteristics T_A = 25°C unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) (I_C = 1.0 mAdc, I_B = 0)	150		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	160		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	5.0		Vdc
I_{CBO}	Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)		50 50	nAdc μAdc
I_{EBO}	Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		50	nAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	50 60 50	240	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		0.20 0.5	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		1.0 1.0	Vdc

PNP General Purpose Amplifier (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

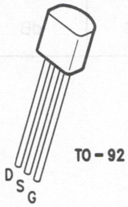
Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	100	300	MHz
c_{obo}	Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		6.0	pF
NF	Noise Figure ($I_C = 250$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 10 Hz to 15.7 kHz)		8.0	dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 74.

National Semiconductor

2N5457 MMBF5457
2N5458 MMBF5458
2N5459 MMBF5459



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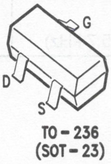


TL/G/10100-6

N-Channel JFET Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Typ	Max	Units
OFF CHARACTERISTICS						
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage ($I_G = -10\ \mu Adc, V_{DS} = 0$)		−25			Vdc
I_{GSS}	Gate Reverse Current ($V_{GS} = -15$ Vdc, $V_{DS} = 0$) ($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)				−1.0 −200	nAdc
$V_{GS(off)}$	Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	2N5457 2N5458 2N5459	−0.5 −1.0 −2.0		−6.0 −7.0 −8.0	Vdc
V_{GS}	Gate Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 100\ \mu Adc$) ($V_{DS} = 15$ Vdc, $I_D = 200\ \mu Adc$) ($V_{DS} = 15$ Vdc, $I_D = 400\ \mu Adc$)	2N5457 2N5458 2N5459		−2.5 −3.5 −4.5		Vdc
ON CHARACTERISTICS						
I_{DSS}	Zero-Gate-Voltage Drain Current, (Note 1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	2N5457 2N5458 2N5459	1.0 2.0 4.0	3.0 6.0 9.0	5.0 9.0 16	mAdc

N-Channel JFET Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter	Min	Typ	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
$\|y_{fs}\|$	Forward Transfer Admittance Common Source, (Note 1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz) 2N5457	1000		5000	µmhos
	2N5458	1500		5500	
	2N5459	2000		6000	
$\|y_{os}\|$	Output Admittance Common Source, (Note 1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)		10	50	µmhos
C_{iss}	Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		4.5	7.0	pF
C_{rss}	Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		1.5	3.0	pF

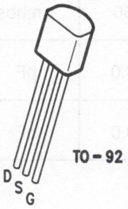
Note 1: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

Note 2: For characteristics curves, see Process 55.

National Semiconductor

2N5484
2N5485
2N5486

MMBF5484
MMBF5485
MMBF5486



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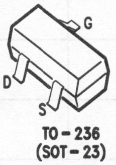


TL/G/10100-6

N-Channel JFET Transistors for RF Amplifiers

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu Adc, V_{DS} = 0$)		−25		Vdc
I_{GSS}	Gate Reverse Current ($V_{GS} = -20$ Vdc, $V_{DS} = 0$) ($V_{GS} = -20$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)			−1.0 −0.2	nAdc μAdc
$V_{GS(off)}$	Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	2N5484 2N5485 2N5486	−0.3 −1.0 −2.0	−3.0 −4.0 −6.0	Vdc
ON CHARACTERISTICS					
I_{DSS}	Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	2N5484 2N5485 2N5486	1.0 4.0 8.0	5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
$\lvert y_{fs} \rvert$	Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	2N5484 2N5485 2N5486	3000 3500 4000	6000 7000 8000	μmhos
$Re(y_{is})$	Input Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 400 MHz)	2N5484 2N5485, 2N5486		100 1000	μmhos
$\lvert y_{os} \rvert$	Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	2N5484 2N5485 2N5486		50 60 75	μmhos

N-Channel JFET Transistors for RF Amplifiers (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

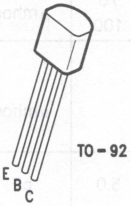
Symbol	Parameter		Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS (Continued)					
$Re(y_{os})$	Output Transconductance				
	$(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 100\ MHz)$	2N5484		75	µmhos
	$(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 400\ MHz)$	2N5485, 2N5486		100	
$Re(y_{fs})$	Forward Transconductance				
	$(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 100\ MHz)$	2N5484	2500		µmhos
	$(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 400\ MHz)$	2N5485	3000		
		2N5486	3500		
C_{iss}	Input Capacitance $(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 1.0\ MHz)$			5.0	pF
C_{rss}	Reverse Transfer Capacitance $(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 1.0\ MHz)$			1.0	pF
C_{oss}	Output Capacitance $(V_{DS} = 15\ Vdc, V_{GS} = 0, f = 1.0\ MHz)$			2.0	pF
FUNCTIONAL CHARACTERISTICS					
NF	Noise Figure				
	$(V_{DS} = 15\ Vdc, V_{GS} = 0, R_G = 1.0\ M\Omega, f = 1.0\ kHz)$			2.5	dB
	$(V_{DS} = 15\ Vdc, I_D = 1.0\ mAdc, R_G \approx 1.0\ k\Omega, f = 100\ MHz)$	2N5484		3.0	
	$(V_{DS} = 15\ Vdc, I_D = 4.0\ mAdc, R_G \approx 1.0\ k\Omega, f = 100\ MHz)$	2N5485, 2N5486		2.0	
	$(V_{DS} = 15\ Vdc, I_D = 4.0\ mAdc, R_G \approx 1.0\ k\Omega, f = 400\ MHz)$	2N5485, 2N5486		4.0	
G_{ps}	Common Source Power Gain				
	$(V_{DS} = 15\ Vdc, I_D = 1.0\ mAdc, f = 100\ MHz)$	2N5484	16	25	dB
	$(V_{DS} = 15\ Vdc, I_D = 4.0\ mAdc, f = 100\ MHz)$	2N5485, 2N5486	18	30	
	$(V_{DS} = 15\ Vdc, I_D = 4.0\ mAdc, f = 400\ MHz)$	2N5485, 2N5486	10	20	

Note 1: For characteristics curves, see Process 50.

National Semiconductor

2N5551

MMBT5551



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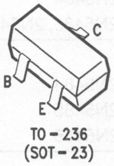


TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	160		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	180		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	6.0		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 120$ Vdc, $I_E = 0$, $T_A = 100°C$)		 50 50	 nAdc μAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		50	nAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	 80 80 20	 250 	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		 0.15 0.25	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		 1.0 1.0	Vdc

NPN General Purpose Amplifier (Continued)

Electrical Characteristics T_A = 25°C unless otherwise noted (Continued)

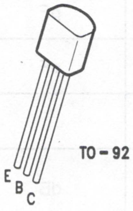
Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	100	300	MHz
C_{obo}	Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		6.0	pF
C_{ibo}	Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		20	pF
h_{fe}	Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	50	200	
NF	Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 10 Hz to 15.7 kHz)		8.0	dB

Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

Note 2: For characteristics curves, see Process 16.

National Semiconductor

2N5771



TL/G/10100-1

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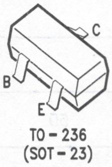


TL/G/10100-5

PNP Switching Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc) (Note 1)	15		Vdc
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc)	15		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc)	15		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc)	4.5		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 8.0$ Vdc)		10	nA
I_{CES}	Collector Cutoff Current ($V_{CE} = 8.0$ Vdc) ($V_{CE} = 8.0$ Vdc, $T_A = 125°C$)		10 5.0	nA μA
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 4.5$ Vdc)		1.0	μA
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 0.5$ Vdc) (Note 1) ($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc) (Note 1) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) (Note 1) ($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc, $T_A = -55°C$)	35 50 40 20	 120 	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		 0.15 0.18 0.6	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	0.75	 0.8 0.95 1.5	Vdc

PNP Switching Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

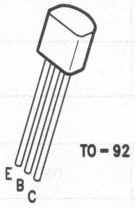
Symbol	Parameter	Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS				
C_{cb}	Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, f = 140 kHz)		3.0	pF
C_{eb}	Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, f = 140 kHz)		3.5	pF
h_{fe}	Small-Signal Current Gain ($I_C = 10$ mA, $V_{CE} = 10$ Vdc, f = 100 MHz)	8.5		
SWITCHING CHARACTERISTICS				
t_s	Storage Time ($I_C = 10$ mAdc, $I_{B1} \approx I_{B2} \approx 10$ mAdc)		20	ns
t_{on}	Turn-On Time ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		15	ns
t_{off}	Turn-Off Time ($I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)		20	ns

Note 1: Pulse Length = 300 μs, Duty Cycle = 1.0%.

Note 2: For characteristics curves, see Process 65.

National Semiconductor

2N6427 MMBT6427 MPQ6427*



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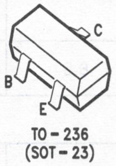

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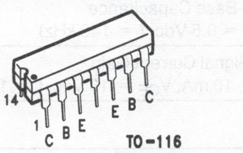


TL/G/10100-7

NPN Darlington Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 10$ mAdc, $I_B = 0$)	40			Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	40			Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	12			Vdc
I_{CEO}	Collector Cutoff Current ($V_{CE} = 25$ Vdc, $I_B = 0$)			1.0	μAdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)			50	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)			50	nAdc
ON CHARACTERISTICS					
h_{FE}	DC Current Gain, (Note 1) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	 10,000 20,000 14,000		 100,000 200,000 140,000	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 500$ mAdc, $I_B = 0.5$ mAdc)		 0.71 0.9	 1.2 1.5	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 0.5$ mAdc)		1.52	2.0	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)		1.24	1.75	Vdc

*16-SOIC version also available. Contact factory.

NPN Darlington Transistor (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

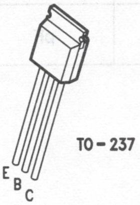
Symbol	Parameter	Min	Typ	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
C_{obo}	Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		5.4	7.0	pF
C_{ibo}	Input Capacitance ($V_{BE} = 1.0$ Vdc, $I_C = 0$, f = 1.0 MHz)		10	15	pF

Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 05.

National Semiconductor

2N6715



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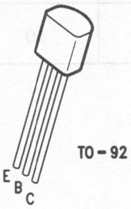
PN6715



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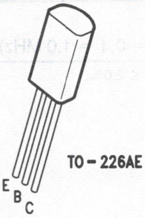
MPS6715



TL/G/10100-4

NPN General Purpose Amplifier

Electrical Characteristics T_A = 25°C unless otherwise noted

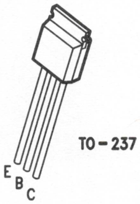
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) (I_C = 10 mAdc, I_B = 0)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	50		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	5.0		Vdc
I_{CBO}	Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		0.1	μAdc
I_{EBO}	Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		0.1	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)	 60 50	 250	
$V_{CE(sat)}$	Collector-Emitter On Voltage (I_C = 1000 mAdc, I_B = 100 mAdc)		0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage (I_C = 1000 mAdc, V_{CE} = 1.0 Vdc)		1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
C_{cb}	Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		30	pF
h_{fe}	Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2.5	25	

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 38.

National Semiconductor

2N6717 MPS6717



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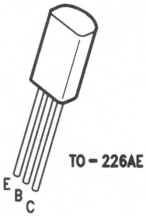


TL/G/10100-4

NPN General Purpose Amplifier

Electrical Characteristics T_A = 25°C unless otherwise noted

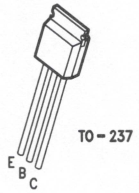
Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) (I_C = 1.0 mAdc, I_B = 0)	MPS6717	80		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS6717	80		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		5.0		Vdc
I_{CBO}	Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	MPS6717		0.1	μAdc
I_{EBO}	Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)			10	μAdc
ON CHARACTERISTICS (Note 1)					
h_{FE}	DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		 80 50	 250	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc)			0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
C_{cb}	Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)			30	pF
h_{fe}	Small-Signal Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		2.5	25	

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 39.

National Semiconductor

2N6724
2N6725



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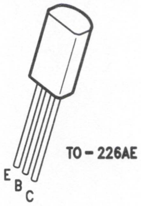
MPS6724
MPS6725



TL/G/10100-4

NPN Darlington Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

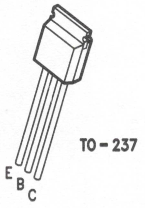
Symbol	Parameter		Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	2N6724/MPS6724 2N6725/MPS6725	40 50		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	2N6724/MPS6724 2N6725/MPS6725	50 60		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		12		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	2N6724/MPS6724 2N6725/MPS6725		100 100	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)			100	nAdc
ON CHARACTERISTICS (Note 1)					
h_{FE}	DC Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		25,000 4,000	40,000	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 2.0$ mAdc)			1.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)			2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current-Gain—Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		100	1000	MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)			10	pF

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 05.

National Semiconductor

2N6727



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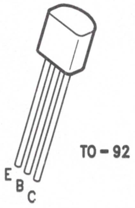
PN6727



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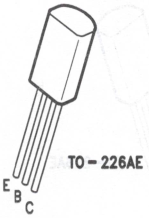
MPS6727



TL/G/10100-4

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

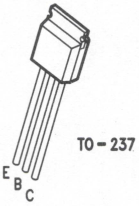
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	40		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	50		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	5.0		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		0.1	μAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		0.1	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)	 60 50	 250	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		30	pF
h_{fe}	Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	2.5	25	

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 78.

National Semiconductor

2N6729 MPS6729



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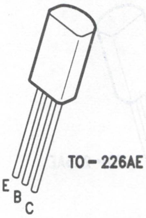


TL/G/10100-4

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

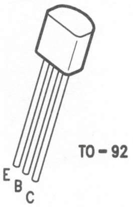
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	80		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	80		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	5.0		Vdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_E = 0$)		10	μAdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_C = 0$)		0.1	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)	 80 50	 250	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 10$ mAdc)		0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		30	pF
h_{fe}	Small-Signal Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	2.5	25	

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 79.

National Semiconductor

2N7052



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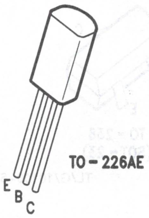
2N7053



TL/G/10100-4

NPN Darlington Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

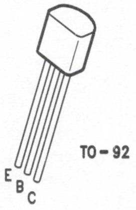
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$)	100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc), (Note 1)	100		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100$ mAdc)	12		V
I_{CBO}	Collector Cutoff Current ($V_{CB} = 80$ Vdc)		100	nA
I_{CES}	Collector Cutoff Current ($V_{CE} = 80$ Vdc)		200	nA
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 7.0$ Vdc)		100	nA
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain, (Note 1) ($V_{CE} = 5$ Vdc, $I_C = 100$ mAdc) ($V_{CE} = 5$ Vdc, $I_C = 1.0$ Adc)	 10,000 1,000	 20,000	dc
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		1.5	V
$V_{BE(on)}$	Base-Emitter On Voltage ($V_{BE} = 5$ Vdc, $I_C = 100$ mAdc)		2.0	V
SMALL-SIGNAL CHARACTERISTICS				
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)		8.0	pF
f_T	Transition Frequency ($V_{CE} = 5.0$ Vdc, $I_C = 100$ mAdc)	200		MHz

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

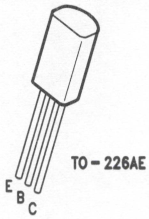
Note 2: For characteristics curves, see Process 06.

National Semiconductor

MPSA06 MPSW06 MMBTA06



TL/G/10100-1



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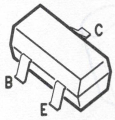


TO-236
(SOT-23)

TL/G/10100-5

NPN General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

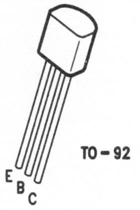
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	80		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	4.0		Vdc
I_{CEO}	Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		0.1	μAdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 80$ Vdc, $I_E = 0$)		0.1	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	 50 50		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		0.25	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product ($I_C = 10$ mA, $V_{CE} = 10$V, f = 100 MHz)	100		MHz

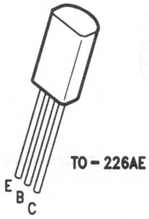
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

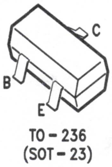
Note 2: For characteristics curves, see Process 12.

National Semiconductor

MPSA13 MPSW13 MMBTA13







NPN Darlington Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc, I_B = 0$)	30		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 30\ Vdc, I_E = 0$)		100	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 10\ Vdc, I_C = 0$)		100	nAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain ($I_C = 10\ mAdc, V_{CE} = 5.0\ Vdc$) ($I_C = 100\ mAdc, V_{CE} = 5.0\ Vdc$)	 5000 10,000		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 100\ mAdc, I_B = 0.1\ mAdc$)		1.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 100\ mAdc, V_{CE} = 5.0\ Vdc$)		2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product, (Note 2) ($I_C = 10\ mAdc, V_{CE} = 5.0\ Vdc, f = 100\ MHz$)	125		MHz

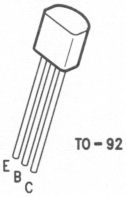
Note 1: Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

Note 2: $f_T = |h_{fe}| \times f_{test}$.

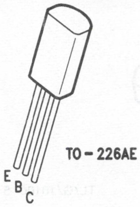
Note 3: For characteristics curves, see Process 05.

National Semiconductor

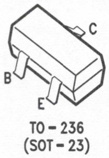
MPSA42 MPSW42 MMBTA42



TL/G/10100-1



TL/G/10100-4



TL/G/10100-5

NPN High Voltage Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

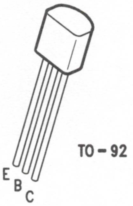
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) $(I_C = 1.0 \text{ mAdc}, I_B = 0)$	300		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage $(I_C = 100\ \mu\text{Adc}, I_E = 0)$	300		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage $(I_E = 100\ \mu\text{Adc}, I_C = 0)$	6.0		Vdc
I_{CBO}	Collector Cutoff Current $(V_{CB} = 200 \text{ Vdc}, I_E = 0)$ $(V_{CB} = 160 \text{ Vdc}, I_E = 0)$		0.1	μAdc
I_{EBO}	Emitter Cutoff Current $(V_{EB} = 6.0 \text{ Vdc}, I_C = 0)$ $(V_{EB} = 4.0 \text{ Vdc}, I_C = 0)$		0.1	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain $(I_C = 1.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ $(I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$ $(I_C = 30 \text{ mAdc}, V_{CE} = 10 \text{ Vdc})$	 25 40 40		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage $(I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc})$		0.5	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage $(I_C = 20 \text{ mAdc}, I_B = 2.0 \text{ mAdc})$		0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product $(I_C = 10 \text{ mAdc}, V_{CE} = 20 \text{ Vdc}, f = 100 \text{ MHz})$	50		MHz
C_{cb}	Collector-Base Capacitance $(V_{CB} = 20 \text{ Vdc}, I_E = 0, f = 1.0 \text{ MHz})$		3.0	pF

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

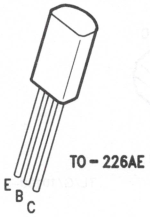
Note 2: For characteristics curves, see Process 48.

National Semiconductor

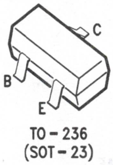
MPSA56 MPSW56 MMBTA56



TL/G/10100-1



TL/G/10100-4



TL/G/10100-5

PNP General Purpose Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

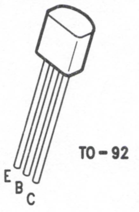
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	80		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	4.0		Vdc
I_{CEO}	Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		0.1	μAdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 80$ Vdc, $I_E = 0$)		0.1	μAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	 50 50		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		0.25	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, f = 100 MHz)	50		MHz

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

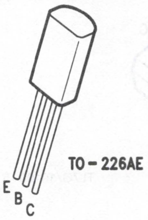
Note 2: For characteristics curves, see Process 67.

National Semiconductor

MPSA64 MPSW64 MMBTA64



TL/G/10100-1



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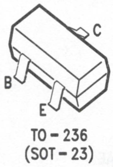


TL/G/10100-5

PNP Darlington Transistor

Electrical Characteristics T_A = 25°C unless otherwise noted

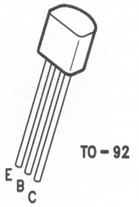
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	30		Vdc
I_{CBO}	Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		100	nAdc
I_{EBO}	Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		100	nAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	10,000 10,000		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.01 mAdc) (I_C = 100 mAdc, I_B = 0.1 mAdc)		1.0 1.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	125		MHz

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

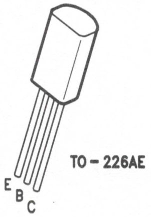
Note 2: For characteristics curves, see Process 61.

National Semiconductor

MPSA92 MPSW92 MMBTA92



TL/G/10100-1



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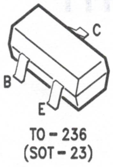


TL/G/10100-5

PNP High Voltage Amplifier

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

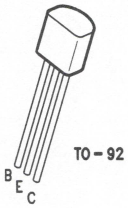
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	300		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	300		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	5.0		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)		0.25	μAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		0.1	μAdc
ON CHARACTERISTICS (Note 1)				
h_{FE}	DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	25 40 25		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		0.5	Vdc
$V_{BE(sat)}$	Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	50		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		6.0	pF

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 76.

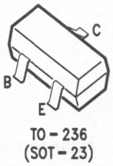
National Semiconductor

MPSH10
MPSH11



TL/G/10100-3

MMBTH10
MMBTH11



TL/G/10100-5

NPN RF Transistors

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	25		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	30		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	3.0		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)		100	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)		100	nAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	60		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 4.0$ mAdc, $I_B = 0.4$ mAdc)		0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)		0.95	Vdc

NPN RF Transistors (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter		Min	Max	Units
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current-Gain—Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		650		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)			0.7	pF
C_{rb}	Common-Base Feedback Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	MPS-H10 (Note 2)	0.35	0.65	pF
		MPS-H11 (Note 3)	0.6	0.9	
$rb'C_c$	Collector-Base Time Constant ($I_C = 4.0$ mAdc, $V_{CB} = 10$ Vdc, f = 31.8 MHz)			9.0	ps

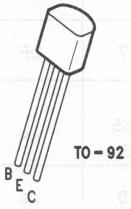
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 42.

Note 3: For characteristics curves, see Process 47.

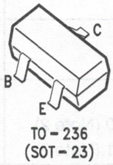
National Semiconductor

MPSH20



TL/G/10100-3

MMBTH20



TL/G/10100-5

NPN RF Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

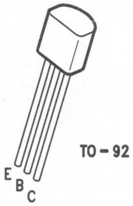
Symbol	Parameter	Min	Typ	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	30			Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	40			Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	4.0			Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)			50	nAdc
ON CHARACTERISTICS					
h_{FE}	DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	25			
SMALL-SIGNAL CHARACTERISTICS					
f_T	Current-Gain—Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	400	620		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		0.5	0.65	pF
$rb'C_c$	Collector-Base Time Constant $I_E = 4.0$ mAdc, $V_{CB} = 10$ Vdc, f = 31.8 MHz)		10		ps
	Conversion Gain (213 MHz to 45 MHz) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, Oscillator Injection = 200 mVdc)	18	23		dB

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

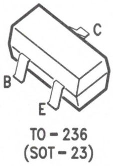
Note 2: For characteristics curves, see Process 49.

National Semiconductor

MPSH81 MMBTH81



TL/G/10100-1



TL/G/10100-5

PNP RF Transistor

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

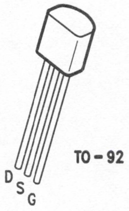
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage, (Note 1) ($I_C = 1.0$ mAdc, $I_B = 0$)	20		Vdc
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	20		Vdc
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	3.0		Vdc
I_{CBO}	Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)		100	nAdc
I_{EBO}	Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)		100	nAdc
ON CHARACTERISTICS				
h_{FE}	DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	60		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)		0.5	Vdc
$V_{BE(on)}$	Base-Emitter On Voltage ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)		0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
f_T	Current-Gain—Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	600		MHz
C_{cb}	Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		0.85	pF
C_{ce}	Collector-Emitter Capacitance ($I_B = 0$, $V_{CB} = 10$ Vdc, f = 1.0 MHz)		0.65	pF

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: For characteristics curves, see Process 75.

National Semiconductor

J108
J109
J110



TL/G/10100-2

N-Channel JFET Switch

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

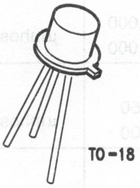
Symbol	Parameter	Min	Max	Units
OFF CHARACTERISTICS				
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage $(V_{DS} = 0, I_G = -10\ \mu Adc)$	−25		Vdc
I_{GSS}	Gate Reverse Current $(V_{GS} = -15\ Vdc, V_{DS} = 0)$ $(V_{GS} = -15\ Vdc, V_{DS} = 0, T_A = 100°C)$		 −3.0 −200	nAdc
$V_{GS(off)}$	Gate Source Cutoff Voltage $(V_{DS} = 15\ Vdc, I_D = 10\ nAdc)$ J108 J109 J110	 −3.0 −2.0 −0.5	 −10 −6.0 −4.0	Vdc
ON CHARACTERISTICS				
I_{DSS}	Zero-Gate-Voltage Drain Current, (Note 1) $(V_{DS} = 15\ Vdc, V_{GS} = 0)$ J108 J109 J110	 80 40 10		mAdc
$r_{DS(on)}$	Drain-Source-On-Resistance $(V_{DS} \leq 0.1Vdc, V_{GS} = 0)$ J108 J109 J110		 8.0 12 18	Ω
SMALL-SIGNAL CHARACTERISTICS				
$C_{dg(on)} +$ $C_{sg(on)}$	Drain Gate + Source Gate On-Capacitance $(V_{DS} = 0\ Vdc, V_{GS} = 0, f = 1.0\ MHz)$		85	pF
$C_{dg(off)}$	Drain Gate Off-Capacitance $(V_{DS} = 0\ Vdc, V_{GS} = -10V, f = 1.0\ MHz)$		15	pF
$C_{sg(off)}$	Source Gate Off-Capacitance $(V_{DS} = 0\ Vdc, V_{GS} = -10V, f = 1.0\ MHz)$		15	pF

Note 1: Pulse Duration 300 μs, Duty Cycle ≤ 2.0%.

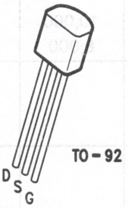
Note 2: For characteristics curves, see Process 58.

National Semiconductor

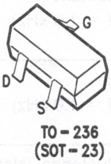
U309 U310 J309 J310 MMBFJ309 MMBFJ310



TL/G/10100-9



TL/G/10100-2



TL/G/10100-6

N-Channel JFET Transistor for RF Amplifiers

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter		Min	Typ	Max	Units
OFF CHARACTERISTICS						
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu Adc$, $V_{DS} = 0$)		−25			Vdc
I_{GSS}	Gate Reverse Current ($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 25°C$) ($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 125°C$)				−1.0 −1.0	nA μA
$V_{GS(off)}$	Gate Source Cutoff Voltage ($V_{DS} = 10$ Vdc, $I_D = 1.0$ nAdc)	J309 J310	−1.0 −2.0		−4.0 −6.5	Vdc
ON CHARACTERISTICS						
I_{DSS}	Zero-Gate-Voltage Drain Current, (Note 1) ($V_{DS} = 10$ Vdc, $V_{GS} = 0$)	J309 J310	12 24		30 60	mA
$V_{GS(f)}$	Gate-Source Forward Voltage ($V_{DS} = 0$, $I_G = 1.0$ mAdc)				1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
$Re\|y_{is}\|$	Common-Source Input Conductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	J309 J310		0.7 0.5		mmhos
$Re\|y_{os}\|$	Common-Source Output Conductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)			0.25		mmhos
G_{pg}	Common-Gate Power Gain ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)			16		dB
$Re\|y_{fs}\|$	Common-Source Forward Transconductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)			12		mmhos

N-Channel JFET Transistor for RF Amplifiers (Continued)

Electrical Characteristics $T_A = 25°C$ unless otherwise noted (Continued)

Symbol	Parameter		Min	Typ	Max	Units
SMALL-SIGNAL CHARACTERISTICS (Continued)						
$Re\|y_{ig}\|$	Common-Gate Input Conductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)			12		mmhos
g_{fs}	Common-Gate Forward Transconductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	J309 J310	10,000 8,000		20,000 18,000	μmhos
g_{os}	Common-Gate Output Conductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	J309 J310			150 200	μmhos
g_{fg}	Common-Gate Forward Transconductance, (Note 1) ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	J309 J310		13,000 12,000		μmhos
g_{og}	Common-Gate Output Conductance ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	J309 J310		100 150		μmhos
C_{gd}	Gate-Drain Capacitance ($V_{DS} = 0$, $V_{GS} = -10$ Vdc, f = 1.0 MHz)			1.8	2.5	pF
C_{gs}	Gate-Source Capacitance ($V_{DS} = 0$, $V_{GS} = -10$ Vdc, f = 1.0 MHz)			4.3	5.0	pF
FUNCTIONAL CHARACTERISTICS						
NF	Noise Figure ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 450 MHz)			1.5		dB
$\bar{e}_n$	Equivalent Short-Circuit Input Noise Voltge ($V_{DS} = 10$ Vdc, $I_D = 10$ mAdc, f = 100 Hz)			10		$nV/\sqrt{Hz}$

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

Note 2: For characteristics curves, see Process 92.

Section 11
Process Characteristics

Section 11 Contents

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D1-Family Part Number List

Part No.	Package Style
1N628	DO-35
1N629	DO-35
1N658	DO-35
1N660	DO-35
1N661	DO-35
1N3070	DO-35
1N4938	DO-35
IS920	DO-35
IS921	DO-35
IS922	DO-35
IS923	DO-35
BAV19	DO-35
BAV20	DO-35
BAV21	DO-35
BAX16	DO-35
BAY72	DO-35
BAY80	DO-35
FDH400	DO-35
FDH444	DO-35

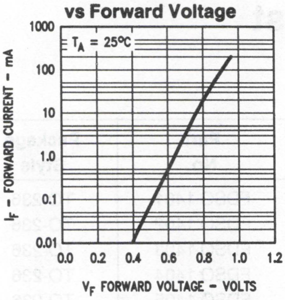
Part No.	Package Style
FDLL628	LL-34
FDLL629	LL-34
FDLL658	LL-34
FDLL660	LL-34
FDLL661	LL-34
FDLL920	LL-34
FDLL921	LL-34
FDLL922	LL-34
FDLL923	LL-34
FDLL3070	LL-34
FDLL4938	LL-34

Part No.	Package Style
FDSO 1401	TO-236
FDSO 1402	TO-236
FDSO 1403	TO-236
FDSO 1404	TO-236
FDSO 1405	TO-236
FDSO 3070	TO-236

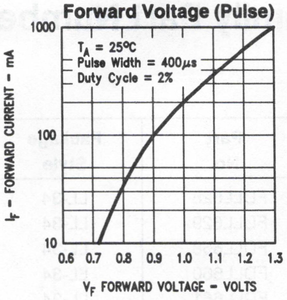
Curve Set Number D1

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted

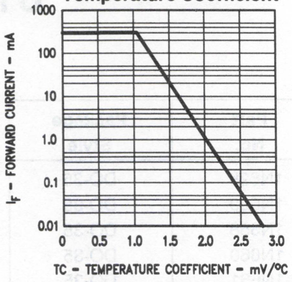
DC Forward Current vs Forward Voltage



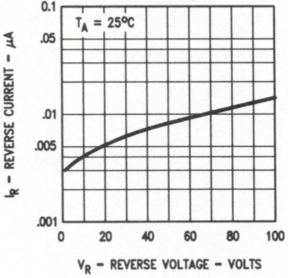
Forward Current vs Forward Voltage (Pulse)



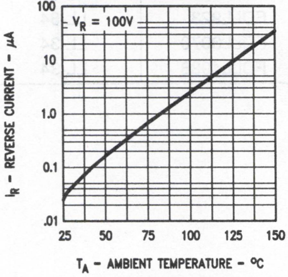
DC Forward Current vs Temperature Coefficient



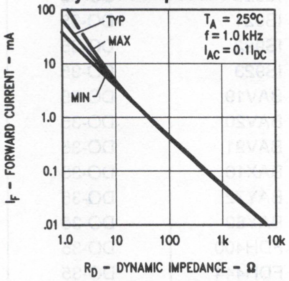
Reverse Current vs Reverse Voltage



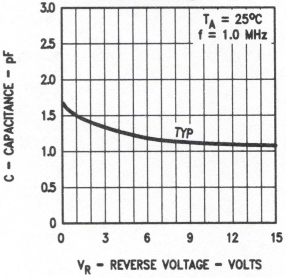
Reverse Current vs Ambient Temperature



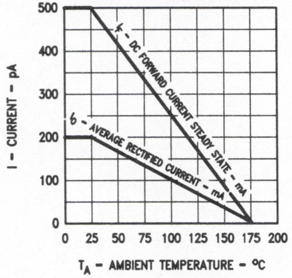
Forward Current vs Dynamic Impedance



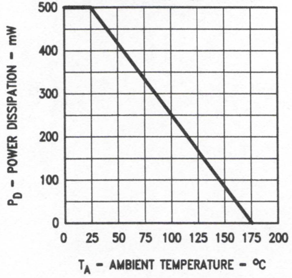
Capacitance vs Reverse Voltage



Average Rectified Current and Forward Current vs Ambient Temperature



Power Derating Curve



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Semiconductor

D2-Family Part Number List

Part No.	Package Style
1N456	DO-35
1N456A	DO-35
1N457	DO-35
1N457A	DO-35
1N458	DO-35
1N458A	DO-35
1N459	D0-35
1N459A	DO-35
1N461A	DO-35
1N462A	DO-35
1N463A	DO-35
1N482B	DO-35
1N483B	DO-35
1N484B	DO-35
1N485B	DO-35
1N3595	DO-35
1N6099	DO-35
BAY73	DO-35
BAY129	DO-35
FDH300	DO-35
FDH333	DO-35

Part No.	Package Style
FDLL300	LL-34
FDLL333	LL-34
FDLL456	LL-34
FDLL456A	LL-34
FDLL457	LL-34
FDLL457A	LL-34
FDLL458	LL-34
FDLL458A	LL-34
FDLL459	LL-34
FDLL459A	LL-34
FDLL461A	LL-34
FDLL462A	LL-34
FDLL463A	LL-34
FDLL482B	LL-34
FDLL483B	LL-34
FDLL484B	LL-34
FDLL485B	LL-34
FDLL3595	LL-34
FDLL6099	LL-34

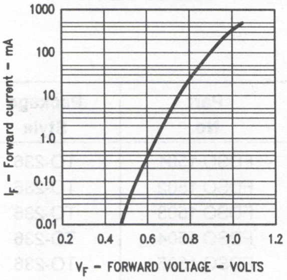
Part No.	Package Style
FDSO 1501	TO-236
FDSO 1502	TO-236
FDSO 1503	TO-236
FDSO 1504	TO-236
FDSO 1505	TO-236
FDSO 3595	TO-236

Curve Set Number D2

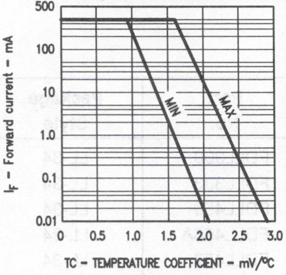
Typical Electrical Characteristic Curves

25°C Ambient Temperature unless otherwise noted (Continued)

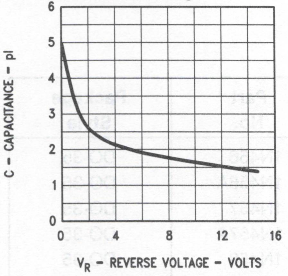
Forward Voltage vs Forward Current



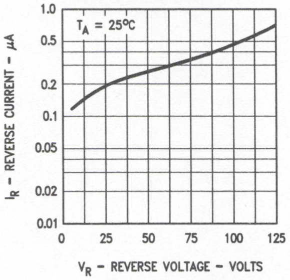
Forward Current vs Temperature Coefficient



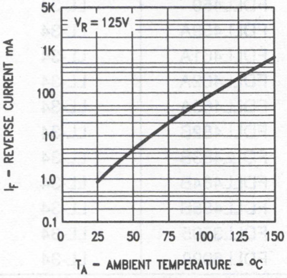
Capacitance vs Reverse Voltage



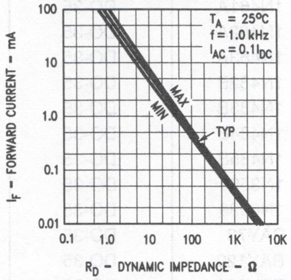
Reverse Voltage vs Reverse Current



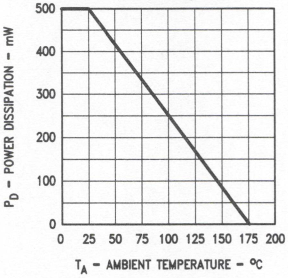
Reverse Current vs Ambient Temperature



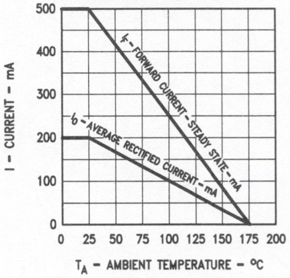
Dynamic Impedance vs Forward Current



Power Derating Curve



Average Rectified Current and Forward Current vs Ambient Temperature



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D3-Family Part Number List

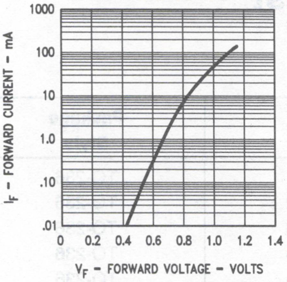
Part No.	Package Style
1N4244	DO-7
1N4376	DO-7
BAY82	DO-7
FD700	DO-7
FD777	DO-7
FDLL700	LL-34
FDLL777	LL-34

Part No.	Package Style
FDSO 1701	TO-236
FDSO 1702	TO-236
FDSO 1703	TO-236
FDSO 1704	TO-236
FDSO 1705	TO-236

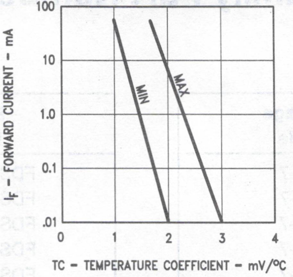
Curve Set Number D3

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted

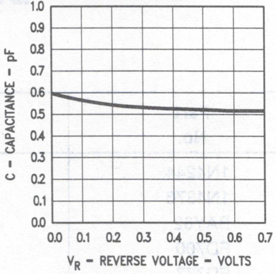
Forward Voltage vs Forward Current



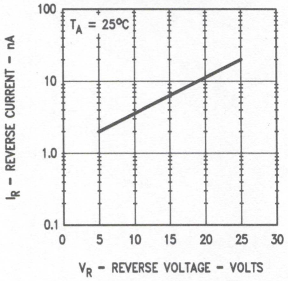
Forward Current vs Temperature Coefficient



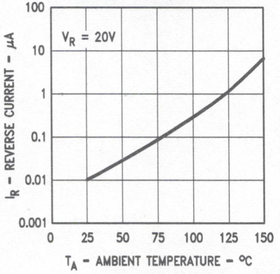
Capacitance vs Reverse Voltage



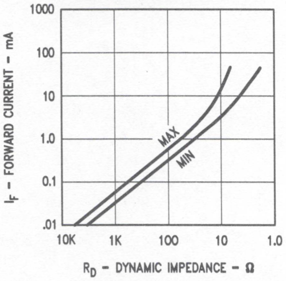
Reverse Voltage vs Reverse Current



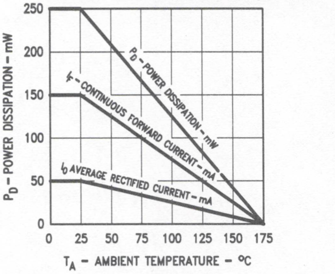
Reverse Current vs Ambient Temperature



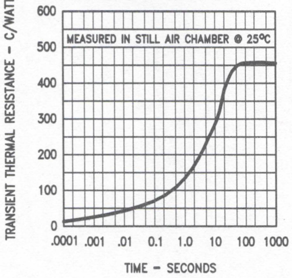
Dynamic Impedance vs Forward Current



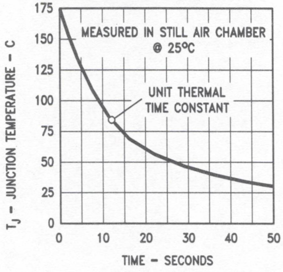
Power Dissipation, Average Rectified Current and Forward Current vs Ambient Temperature



Transient Thermal Resistance vs Time



Junction Temperature vs Time (Cooling Curve)



TL/G/10033-3

D4-Family Part Number List

Part No.	Package Style
1N625	DO-35
1N626	DO-35
1N627	DO-35
1N659	DO-35
1N914	DO-35
1N914A	DO-35
1N914B	DO-35
1N916	DO-35
1N916A	DO-35
1N916B	DO-35
1N3064	DO-35
1N3600	DO-35
1N4009	DO-35
1N4146	DO-35
1N4147	DO-35
1N4148	DO-35
1N4149	DO-35
1N4150	DO-35
1N4151	DO-35
1N4152	DO-35
1N4153	DO-35
1N4154	DO-35
1N4305	DO-35
1N4446	DO-35
1N4447	DO-35
1N4448	DO-35
1N4449	DO-35
1N4450	DO-35
1N4454	DO-35
1N5282	DO-35
BA128	DO-35
BA130	DO-35
BA217	DO-35
BA218	DO-35
BAX13	DO-35
BAY71	DO-35
FDH600	DO-35
FDH666	DO-35
FDH900	DO-35
FDH999	DO-35
FDH1000	DO-35

Pair & Quad

1N4306 } DO-7*
1N4307 }

*See Test Circuit D-18

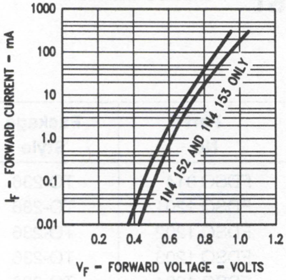
Part No.	Package Style
FDLL600	LL-34
FDLL625	LL-34
FDLL626	LL-34
FDLL627	LL-34
FDLL659	LL-34
FDLL666	LL-34
FDLL900	LL-34
FDLL914	LL-34
FDLL914A	LL-34
FDLL914B	LL-34
FDLL916	LL-34
FDLL916A	LL-34
FDLL916B	LL-34
FDLL999	LL-34
FDLL1000	LL-34
FDLL3064	LL-34
FDLL3600	LL-34
FDLL4146	LL-34
FDLL4147	LL-34
FDLL4148	LL-34
FDLL4149	LL-34
FDLL4150	LL-34
FDLL4151	LL-34
FDLL4152	LL-34
FDLL4153	LL-34
FDLL4154	LL-34
FDLL4305	LL-34
FDLL4446	LL-34
FDLL4447	LL-34
FDLL4448	LL-34
FDLL4449	LL-34
FDLL4450	LL-34
FDLL4454	LL-34

Part No.	Package Style
FDSO 914	TO-236
FDSO 1201	TO-236
FDSO 1202	TO-236
FDSO 1203	TO-236
FDSO 1204	TO-236
FDSO 1205	TO-236
FDSO 4148	TO-236
FDSO 4448	TO-236
BAS16	TO-236
BAV17	TO-236
BAV18	TO-236
BAV70	TO-236
BAV74	TO-236
BAV99	TO-236
BAW56	TO-236
BAW75	TO-236
BAW76	TO-236

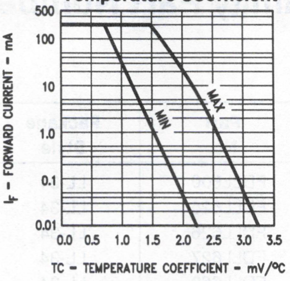
Curve Set Number D4

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted

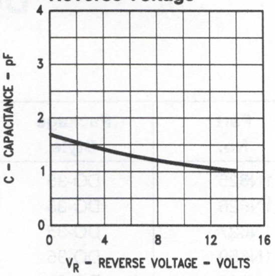
Forward Voltage vs Forward Current



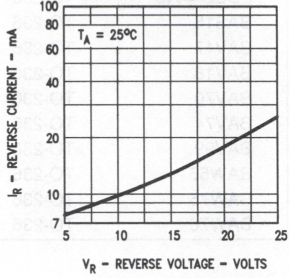
Forward Current vs Temperature Coefficient



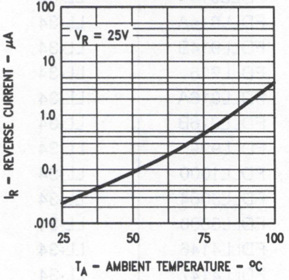
Capacitance vs Reverse Voltage



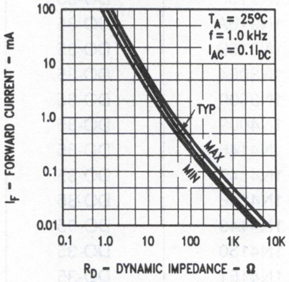
Reverse Current vs Reverse Voltage



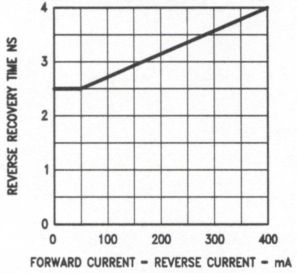
Reverse Current vs Ambient Temperature



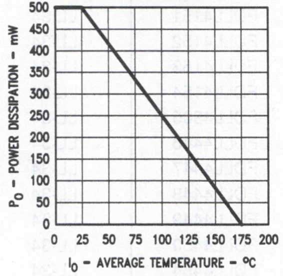
Dynamic Impedance vs Forward Current



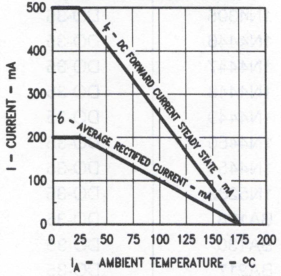
Reverse Recovery Time vs Forward Current (F = IR)



Power Derating Curve



Average Rectified Current and Forward Current vs Ambient Temperature



TL/G/10033-4

D6-Family Part Number List

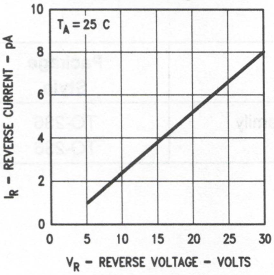
Part No.	Package Style
FJT1100	DO-7
FJT1101	DO-7

Part No.	Package Style
FDSO 1300 Family	TO-236
FDSO 1301	TO-236

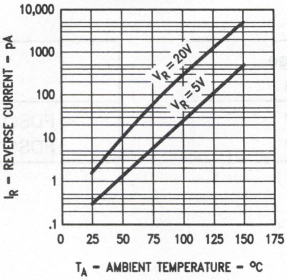
Curve Set Number D6

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted

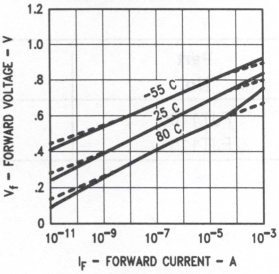
Reverse Current vs Reverse Voltage



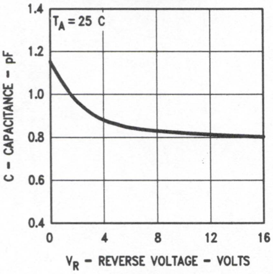
Reverse Current vs Temperature



Forward Voltage vs Forward Current



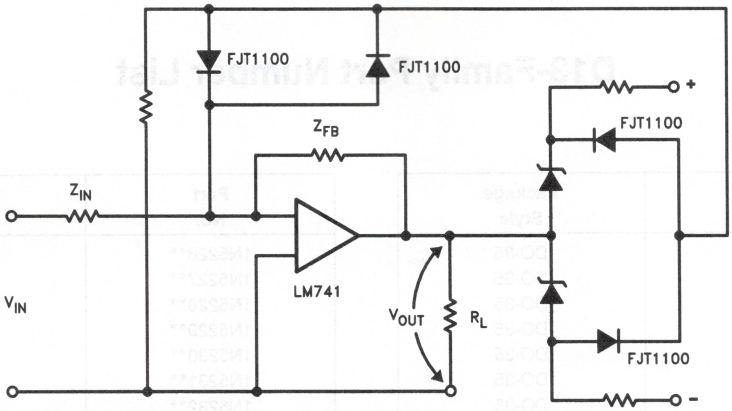
Capacitance vs Reverse Voltage



TL/G/10033-5

Test Circuits

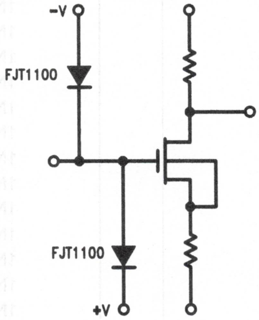
A Bound Circuit for Operational Amplifiers


FJT1100
FJT1100
Z_{FB}
Z_{IN}
FJT1100
V_{IN}
LM741
V_{OUT}
R_L
FJT1100
+
-

TL/G/10033-6

The bound circuit prevents overloading and saturation of operational amplifiers. The circuit has negligible effect on the operational amplifier until overload conditions occur. The use of the low leakage picoampere diode permits realization of extremely high input impedance for normal input voltages.

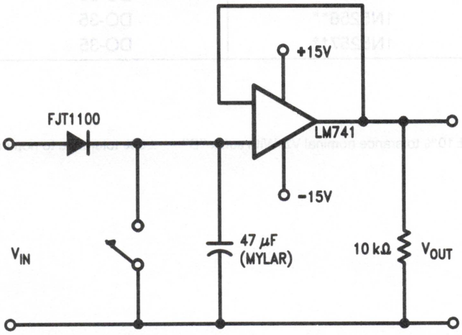
MOS FET Protection Circuit


-V
FJT1100
FJT1100
+V

TL/G/10033-7

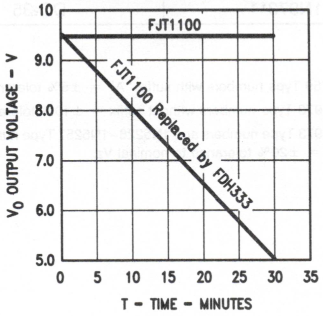
The picoampere diode affords excellent gate voltage protection while maintaining the DC input impedance at about one million megohms. In addition the very low capacity of the FJT1100 will have a relatively small effect on the circuit input capacity.

Peak Follower Circuit


+15V
FJT1100
LM741
-15V
V_{IN}
47 μF (MYLAR)
10 kΩ
V_{OUT}

TL/G/10033-8

Output Voltage of the Peak Follower Circuit vs Time



TL/G/10033-9

A nearly constant voltage peak follower circuit is available by using a picoampere diode. A comparison between the use of the FJT1100 and a "low leakage" FDH333 diode in the circuit is shown in the curves of V_{OUT} vs Time.

National Semiconductor

D13-Family Part Number List

Part No.	Package Style
1N746*	DO-35
1N747*	DO-35
1N748*	DO-35
1N749*	DO-35
1N750*	DO-35
1N751*	DO-35
1N752*	DO-35
1N753*	DO-35
1N754*	DO-35
1N755*	DO-35
1N756*	DO-35
1N757*	DO-35
1N758*	DO-35
1N759*	DO-35
1N957**	DO-35
1N958**	DO-35
1N959**	DO-35
1N960**	DO-35
1N961**	DO-35
1N962**	DO-35
1N963**	DO-35
1N964**	DO-35
1N965**	DO-35
1N966**	DO-35
1N967**	DO-35
1N968**	DO-35
1N969**	DO-35
1N970**	DO-35
1N971**	DO-35
1N972**	DO-35
1N973**	DO-35

Part No.	Package Style
1N5226**	DO-35
1N5227**	DO-35
1N5228**	DO-35
1N5229**	DO-35
1N5230**	DO-35
1N5231**	DO-35
1N5232**	DO-35
1N5233**	DO-35
1N5234**	DO-35
1N5235**	DO-35
1N5236**	DO-35
1N5237**	DO-35
1N5238**	DO-35
1N5239**	DO-35
1N5240**	DO-35
1N5241**	DO-35
1N5242**	DO-35
1N5243**	DO-35
1N5244**	DO-35
1N5245**	DO-35
1N5246**	DO-35
1N5247**	DO-35
1N5248**	DO-35
1N5249**	DO-35
1N5250**	DO-35
1N5251**	DO-35
1N5252**	DO-35
1N5253**	DO-35
1N5254**	DO-35
1N5255**	DO-35
1N5256**	DO-35
1N5257**	DO-35

Note:

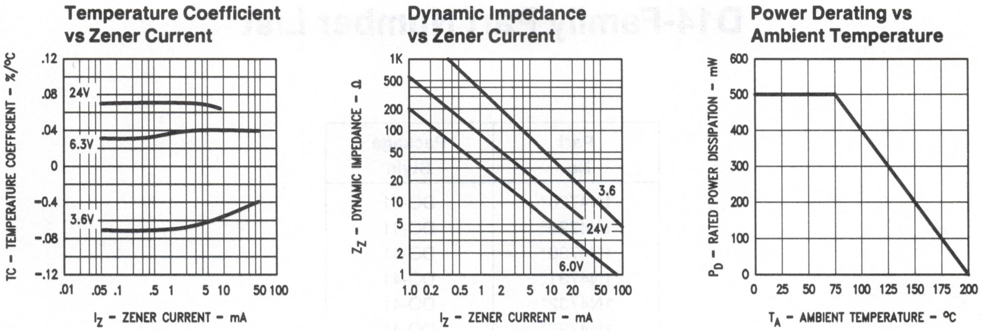
*1N746–1N759 Type numbers with suffix "A" = ±5% tolerance nominal Vz.

**1N957–1N973 Type numbers without suffix = ±10% tolerance to nominal Vz.

**1N957–1N973 Type numbers and 1N5226–1N5257 Type numbers with suffix "A" = ±10% tolerance nominal Vz. With suffix "B" = ±5% tolerance to nominal Vz. No suffix = ±20% tolerance to nominal Vz.

Curve Set Number D13

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted



Temperature Coefficient vs Zener Current

Dynamic Impedance vs Zener Current

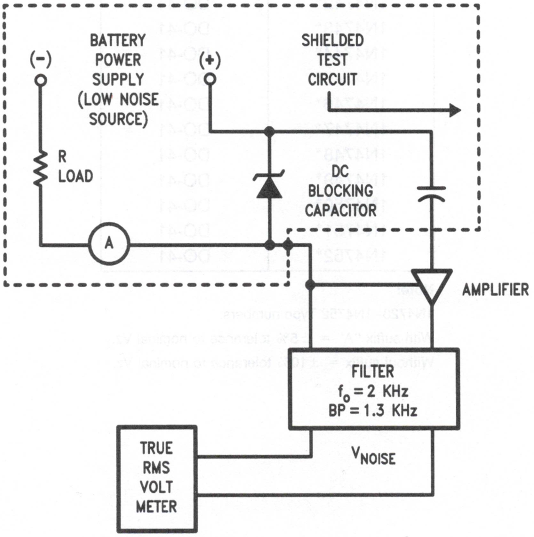
Power Derating vs Ambient Temperature

TL/G/10033-10

Test Circuit

NOISE DENSITY MEASUREMENT CIRCUIT

1N4099–1N4121
1N4620–1N4627



BATTERY
POWER
SUPPLY
(LOW NOISE
SOURCE)
(–)
(+)
SHIELDED
TEST
CIRCUIT
R
LOAD
DC
BLOCKING
CAPACITOR
A
AMPLIFIER
FILTER
f_o = 2 KHz
BP = 1.3 KHz
TRUE
RMS
VOLT
METER
V_NOISE

TL/G/10033-11

National Semiconductor

D14-Family Part Number List

Part No.	Package Style
1N4728*	DO-41
1N4729*	DO-41
1N4730*	DO-41
1N4731*	DO-41
1N4732*	DO-41
1N4733*	DO-41
1N4734*	DO-41
1N4735*	DO-41
1N4736*	DO-41
1N4737*	DO-41
1N4738*	DO-41
1N4739*	DO-41
1N4740*	DO-41
1N4742*	DO-41
1N4743*	DO-41
1N4744*	DO-41
1N4745*	DO-41
1N4746*	DO-41
1N4747*	DO-41
1N4748*	DO-41
1N4749*	DO-41
1N4750*	DO-41
1N4751*	DO-41
1N4752*	DO-41

Note:

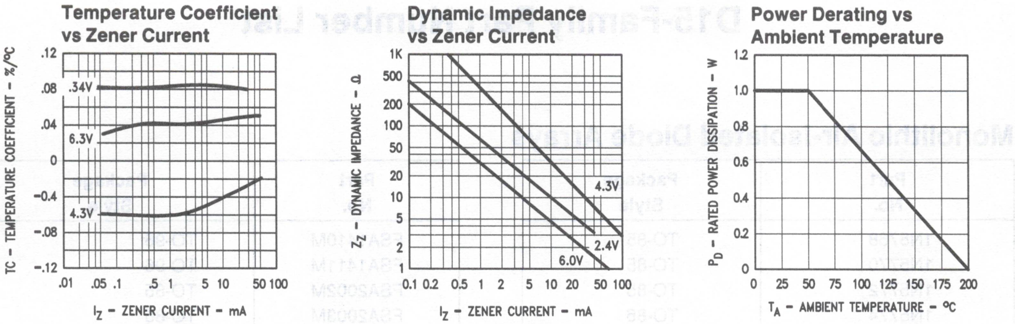
1N4728–1N4752 Type numbers.

With suffix "A" = ±5% tolerance to nominal Vz.

Without suffix = ±10% tolerance to nominal Vz.

Curve Set Number D14

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted



Temperature Coefficient vs Zener Current

Dynamic Impedance vs Zener Current

Power Derating vs Ambient Temperature

TL/G/10033-12

National Semiconductor

D15-Family Part Number List

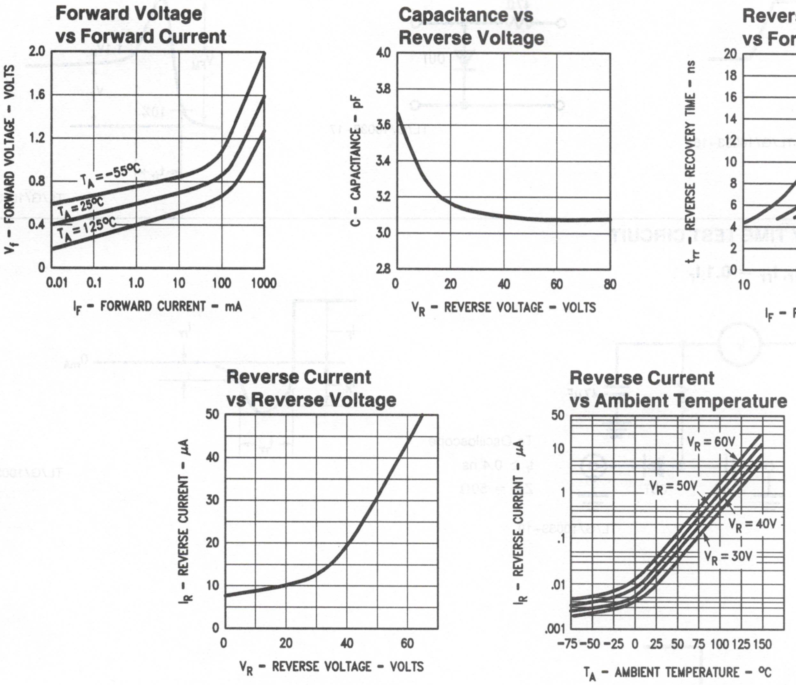
Monolithic Air-Isolated Diode Arrays

Part No.	Package Style
1N5768	TO-85
1N5770	TO-85
1N5772	TO-85
1N5774	TO-86
1N6100	TO-86
1N6101	6B
FASO2501	14 SOIC
FASO2503	14 SOIC
FASO2509	14 SOIC
FASO2510	14 SOIC
FASO2563	14 SOIC
FASO2564	14 SOIC
FASO2565	16 SOIC
FASO2566	16 SOIC
FASO2619	16 SOIC
FASO2620	14 SOIC
FASO2719	16 SOIC
FASO2720	14 SOIC
FASO6101	14 SOIC

Part No.	Package Style
FSA1410M	TO-96
FSA1411M	TO-96
FSA2002M	TO-85
FSA2003M	TO-85
FSA2500M	TO-85
FSA2501M	TO-116-2
FSA2501P	TO-116
FSA2502M	TO-96
FSA2503M	TO-116-2
FSA2503P	TO-116
FSA2504M	TO-86
FSA2508P	9B
FSA2509M	TO-116-2
FSA2509P	TO-116
FSA2510M	TO-116-2
FSA2510P	TO-116
FSA2563M	TO-116-2
FSA2563P	TO-116
FSA2564M	TO-116-2
FSA2564P	TO-116
FSA2565M	TO-116-2
FSA2565P	TO-116
FSA2566M	TO-116-2
FSA2566P	TO-116
FSA2619M	TO-6B (Ceramic DIP)
FSA2619P	TO-9B (Plastic DIP)
FSA2620M	TO-116-2
FSA2620P	TO-116
FSA2621M	TO-86
FSA2719M	6B
FSA2719P	9B
FSA2720M	TO-116-2
FSA2720P	TO-116
FSA2721M	TO-86

Curve Set Number D15

Typical Electrical Characteristic Curves 25°C Ambient Temperature unless otherwise noted

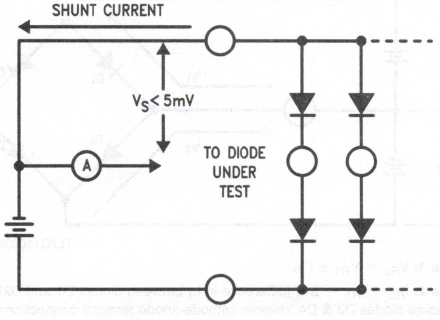


TL/G/10033-13

Test Circuits

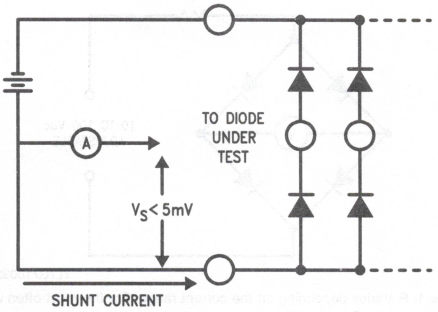
To measure reverse current of an individual diode, the following test circuits are used:

Common Cathode Diodes


SHUNT CURRENT
$V_S < 5mV$
A
TO DIODE UNDER TEST

TL/G/10033-14

Common Anode Diodes

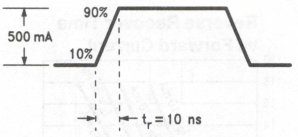

TO DIODE UNDER TEST
A
$V_S < 5mV$
SHUNT CURRENT

TL/G/10033-15

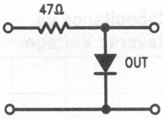
Test Circuits (Continued)

Test requirement for V_{FM} and t_{fr} is as shown below: all leads should be as short as possible

Input Current Pulse

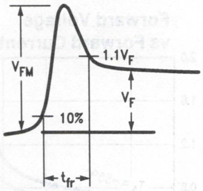

90%
500 mA
10%
$t_r = 10$ ns

TL/G/10033-16



TL/G/10033-17

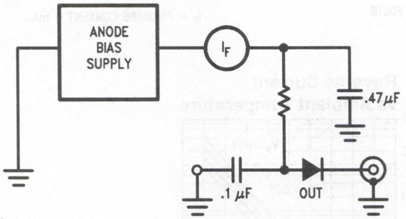
Output Voltage Pulse


1.1V_F
V_{FM}
V_F
10%
t_{fr}

TL/G/10033-18

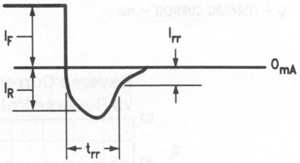
t_{rr} REVERSE RECOVERY TIME TEST CIRCUIT

$I_f = I_r; I_{rr} = 0.1\ I_r$


ANODE
BIAS
SUPPLY
I_F
.47μF
.1 μF
OUT

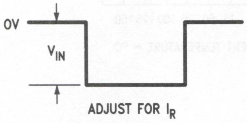
To Oscilloscope
$t_r \geq 0.4$ ns
$Z_{IN} = 50\Omega$

TL/G/10033-19


I_F
I_{rr}
0_{mA}
I_R
t_{rr}

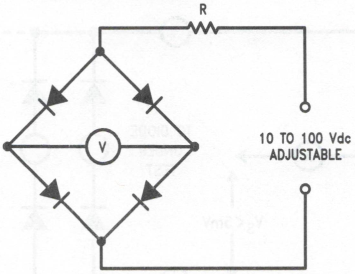
TL/G/10033-21

Pulse Generator
$t_r \leq 5$ ns
$Z_{IN} = 50\Omega$
P.W. = 1 μs
Duty Cycle = 2%


0V
V_{IN}
ADJUST FOR I_R

TL/G/10033-20

ΔV_F BRIDGE MATCHING CIRCUIT


R
V
10 TO 100 Vdc
ADJUSTABLE

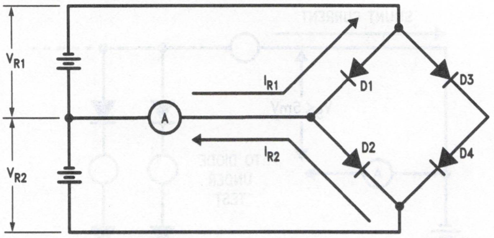
TL/G/10033-22

Note 1: R Varies depending on the current range. For the most often used current ranges, R is as follows:

Current Range (amperes)	R (ohms)
10^{-5} to 10^{-4}	10^6
10^{-4} to 10^{-3}	10^5
10^{-3} to 10^{-2}	10^4
or 10^{-n} to 10^{-n+1}	10^{n+1}

Note 2: V indicates mismtch of assembly.

ΔI_R BRIDGE MATCHING CIRCUIT


V_{R1}
V_{R2}
A
I_{R1}
I_{R2}
D1
D2
D3
D4

TL/G/10033-23

Note 1: $V_{R2} = V_{R1} \pm 1\%$.

Note 2: $I_{R2} - I_{R1} = \Delta I_R$ (difference in I_R between diodes D1 and D2). To measure diodes D3 & D4, reverse cathode-anode terminal connections.

Note 3: A is a center reading pico ammeter. $\Delta / _R$ indicated directly on A.

National Semiconductor

D18-Family Part Number List

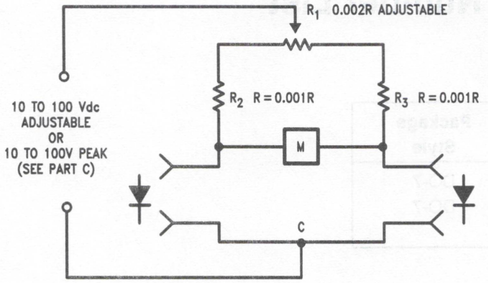
Part No.	Package Style
1N4306	DO-7
1N4307	DO-7
FA Series	

Curve Set Number D18

Test Circuits for 1N4306/7 and FA Series

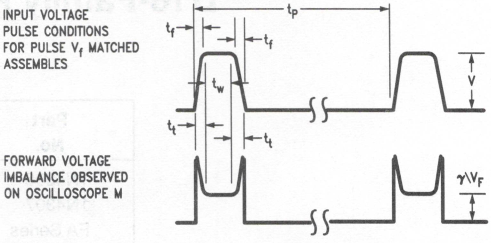
ΔV$_F$ DIODE MATCHING CIRCUITS

a.


R$_1$ 0.002R ADJUSTABLE
R$_2$ R = 0.001R
R$_3$ R = 0.001R
10 TO 100 Vdc ADJUSTABLE OR 10 TO 100V PEAK (SEE PART C)
M
C

TL/G/10033-24

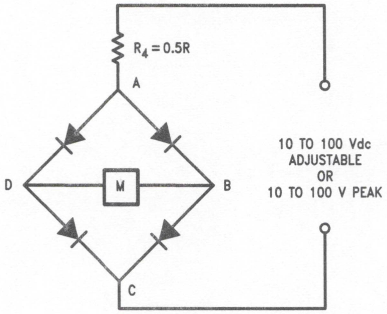
c.


INPUT VOLTAGE PULSE CONDITIONS FOR PULSE V$_f$ MATCHED ASSEMBLES
FORWARD VOLTAGE IMBALANCE OBSERVED ON OSCILLOSCOPE M
t$_p$
t$_f$
t$_f$
t$_w$
t$_t$
t$_t$
V
ΔV$_F$

TL/G/10033-25

t_r	Pulse Rise Time (10 to 90% Amplitude)	= 1.0 μs Max.
t_f	Pulse Fall Time (90 to 10% Amplitude)	= 1.0 μs Max.
t_w	Pulse Width (50% Amplitude)	= 10 ±2.0 μs
t_t	Transient Time	= 1.0 μs Min.
t_p	Period	= 1.0 ms
V	Voltage Input to Cirtcuit "A or B"	= 10V to 100V Adjustable
ΔV$_F$	Forward Voltage Difference Between Diodes (Measured Between Transient Times)	= As Specified.

b.


R$_4$ = 0.5R
A
B
C
D
M
10 TO 100 Vdc ADJUSTABLE OR 10 TO 100 V PEAK

TL/G/10033-26

Note 1: R varies depending on the current range. For the most often used current ranges, R is as follows:

Current Range (Amperes)	R (omhs)
10^{-5} to 10^{-4}	10^5
10^{-4} to 10^{-3}	10^5
10^{-3} to 10^{-2}	10^4
or 10^{-n} to 10^{-n+1}	10^{n+1}

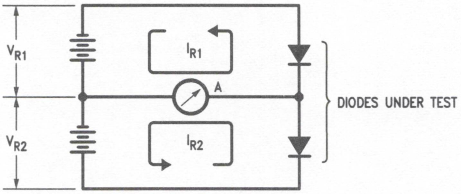
Note 2: The input voltage pulse conditions shown above are employed at National Semiconductor in testing. The user may deviate from the specific conditions above with no variation in results providing the following general conditions are met:

a. $\frac{t_w}{t_p} \leq 0.01$

b. $t_w < 10$ ms

c. Transients occurring during pulse rise and fall times are ignored in observing ΔV$_F$.

ΔI$_R$ DIODE MATCHING CIRCUIT


V$_{R1}$
V$_{R2}$
I$_{R1}$
I$_{R2}$
A
DIODES UNDER TEST

TL/G/10033-27

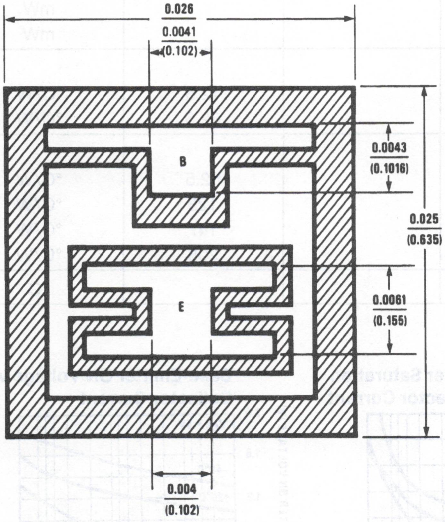
Note 1: $V_{R2} = -V_{R1} \pm 1\%$.

Note 2: $I_{R2} - I_{R1} = \Delta I_R$ (difference in I_R between two diodes under test).

Note 3: A is a center reading pico ammeter.

National Semiconductor

Process 05
NPN Darlington



TL/G/10034–1

DESCRIPTION

Process 05 is a monolithic, double-diffused, silicon epitaxial Darlington. Complement to Process 61.

APPLICATION

This device was designed for applications requiring extremely high current gain at collector currents to 1A.

PRINCIPAL DEVICE TYPES

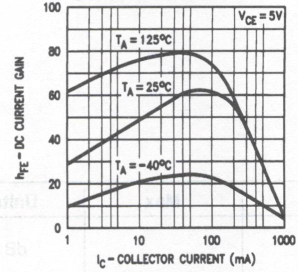
TO-92 EBC: MPSA13
TO-92 ECB: 2N5306
TO-116: MPQA13
TO-202 EBC: D40C1-8, NSDU45
TO-226 EBC: MPS6724, MPSW13
TO-236: MMBTA13
TO-237 EBC: 2N6724

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

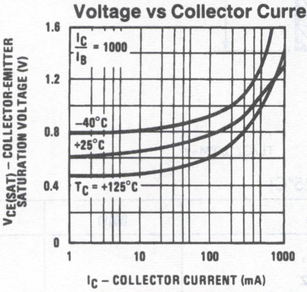
Symbol	Conditions	Min	Typ	Max	Units
NF	I_C = 1 mA V_{CE} = 5V, R_S = 100k, f = 1 kHz		2		dB
C_{CB}	V_{CB} = 10V, I_E = 0, f = 1 MHz		4	6	pF
h_{FE}	I_C = 10 mA, V_{CE} = 5V	4,000			
	I_C = 100 mA, V_{CE} = 5V	8,000	40,000	200,000	
	I_C = 1A, V_{CE} = 5V	3,000			
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 10 μA			1.0	V
	I_C = 100 mA, I_B = 100 μA			1.5	V
$V_{BE(ON)}$	I_C = 10 mA, V_{CE} = 5V		1.2	1.4	V
	I_C = 100 mA, V_{CE} = 5V		1.3	1.8	V
h_{fe}	I_C = 10 mA, V_{CE} = 5.0V, f = 1 kHz		60,000		
BV_{CES}	I_C = 100 μA	40			V
BV_{EBO}	I_E = 10 μA	12			V
I_{CES}	V_{CE} = 15V, V_{BE} = 0			100	nA
I_{CBO}	V_{CB} = 30V, I_E = 0			100	nA
I_{EBO}	V_{EB} = 10V, I_C = 0			100	nA
$P_{D(max)}$					
TO-202	T_C = 25°C	10			W
	T_A = 25°C	2			W
TO-226	T_A = 25°C	1			W

Symbol	Conditions	Min	Typ	Max	Units
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW
θ_{JC}					
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_C = 25°C$			62.5	°C/W
θ_{JA}					
TO-202	$T_A = 25°C$			62.5	°C/W
TO-226	$T_A = 25°C$			125	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

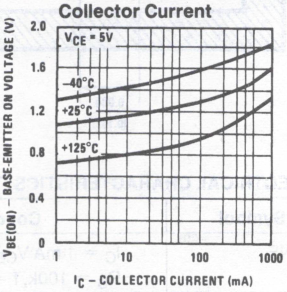
DC Pulsed Current Gain vs Collector Current



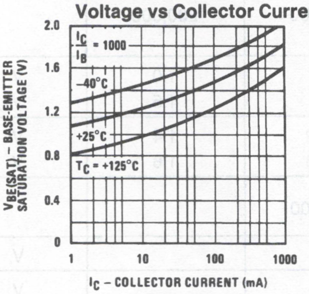
Collector-Emitter Saturation Voltage vs Collector Current



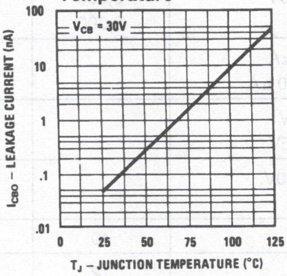
Base-Emitter ON Voltage vs Collector Current



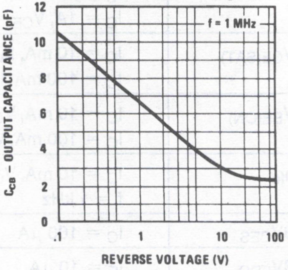
Base -Emitter Saturation Voltage vs Collector Current



Collector-Base Diode Reverse Current vs Temperature



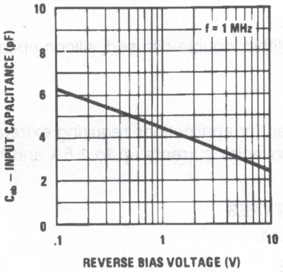
Output Capacitance vs Reverse Bias Voltage



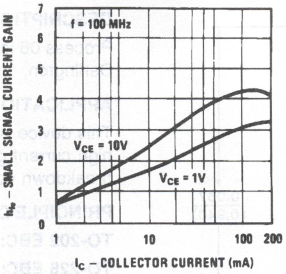
TL/G/10034-2

Process 05

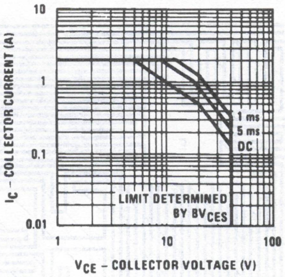
Input Capacitance vs Reverse Bias Voltage



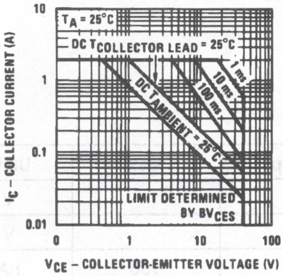
Small Signal Current Gain vs Collector Current



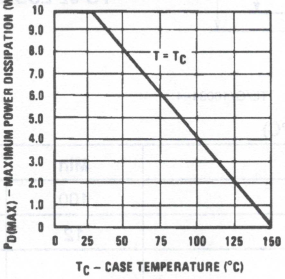
Safe Operating Area TO-202



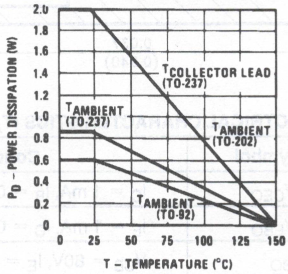
Safe Operating Area TO-237



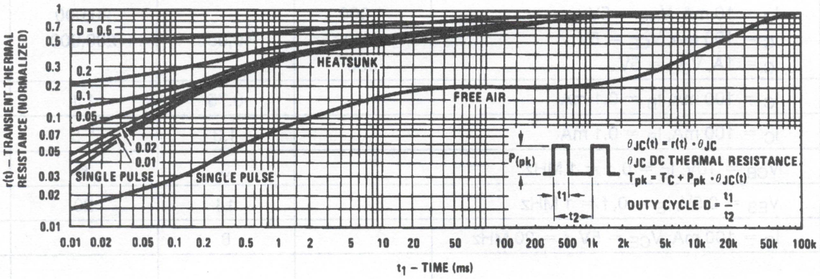
Maximum Power Dissipation TO-202 vs Case Temperature



Thermal Derating Curve



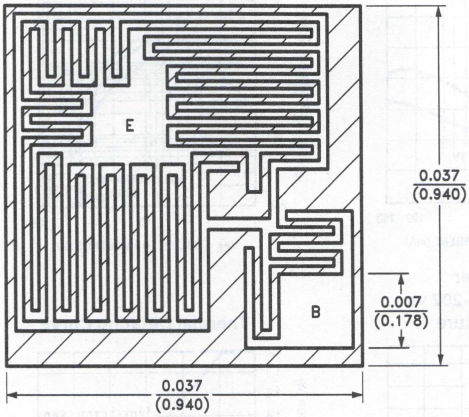
Thermal Response in TO-202 Package



TL/G/10034-3

National Semiconductor

Process 06
NPN Darlington



TL/G/10034-4

DESCRIPTION

Process 06 is a monolithic, double-diffused, silicon epitaxial Darlington.

APPLICATION

This device is designed for applications requiring extremely high current gain at collector currents up to 1.5A and high breakdown voltage.

PRINCIPLE DEVICE TYPES

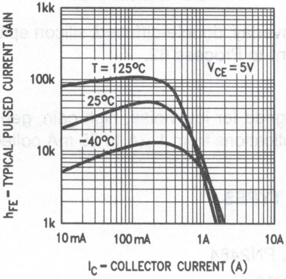
TO-202 EBC: NSDU45A
TO-226 EBC: 2N7053
TO-237 EBC: 92PU45A
TO-92 EBC: 2N7052
TO-92 ECB: 2N7051

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

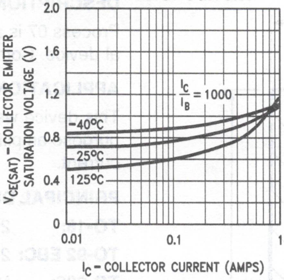
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1$ mA, $I_B = 0$	100			V
BV_{EBO}	$I_E = 1$ mA, $I_C = 0$	12			V
I_{CBO}	$V_{CB} = 80V, I_E = 0$			100	nA
I_{CES}	$V_{CE} = 80V, V_{BE} = 0$			100	nA
I_{EBO}	$V_{EB} = 7V$			100	nA
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$	1,000		20,000	
	$I_C = 100$ mA, $V_{CE} = 5V$	10,000	40,000	200,000	
	$I_C = 1A, V_{CE} = 5V$	500			
$V_{CE(s)}$	$I_C = 100$ mA, $I_B = 0.1$ mA		0.75	1.1	V
$V_{BE(s)}$	$I_C = 100$ mA, $I_B = 0.1$ mA		1.3	1.5	V
C_{cb}	$V_{CB} = 10V, I_E = 0, f = 1$ MHz		3	6	pF
C_{ib}	$V_{EB} = 0.5V, I_E = 0, f = 1$ MHz		14	20	pF
h_{fe}	$I_C = 100$ mA, $V_{CE} = 5V, f = 20$ MHz		8		
$P_{D(max)}$					
TO-202	T_C = 25°C	12			W
	T_A = 25°C	2			W
TO-226	T_A = 25°C	1			W
TO-237	T_C = 25°C	2			W
	T_A = 25°C	850			mW
TO-92	T_A = 25°C	700			mW
$T_{J(max)}$	All Plastic Parts	150			°C

Process 06

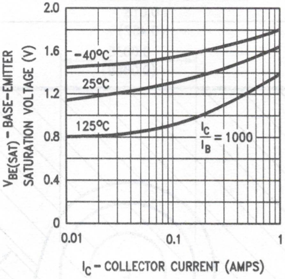
Typical Pulse Current vs Collector Current



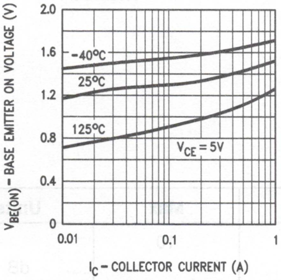
Collector-Emitter Saturation Voltage vs Collector Current



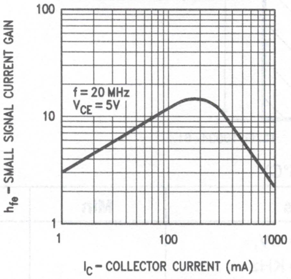
Base-Emitter Saturation Voltage vs Collector Current



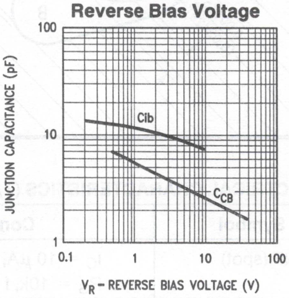
Base-Emitter on Voltage vs Collector Current



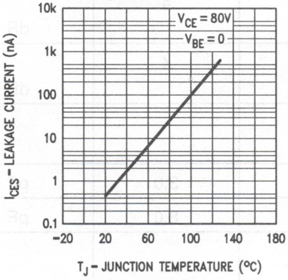
Small Signal Current Gain vs Collector Current



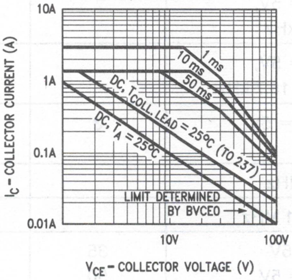
Junction Capacitance vs Reverse Bias Voltage



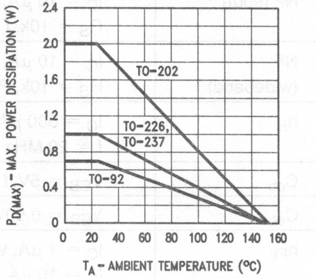
Typical Collector-Emitter Leakage Current vs Temperature



Safe Operating Area TO-226, TO-237



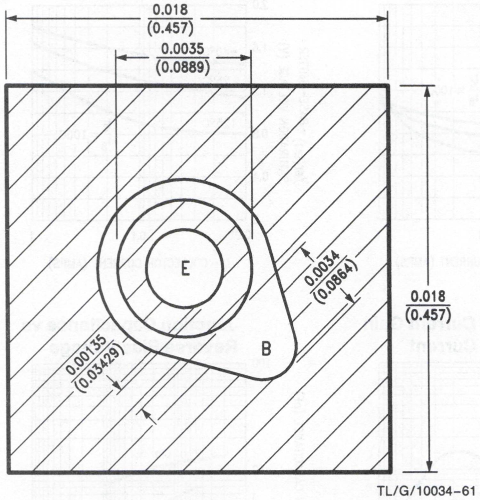
Maximum Power Dissipation vs Ambient Temperature



TL/G/10034-5

National Semiconductor

Process 07
NPN Small Signal



DESCRIPTION

Process 07 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 62.

APPLICATION

This device was designed for low noise, high gain, general purpose amplifier applications from 1 μA to 25 mA collector current.

PRINCIPAL DEVICE TYPES

TO-18:	2N930
TO-92 EBC:	2N5088, PN2484
TO-236:	MMBT5088

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
NF (spot)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, $f = 100$ KHz		3	10	dB
NF (spot)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, $f = 1$ kHz		1.5	4	dB
NF (spot)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, $f = 10$ kHz		1.5	4	dB
NF (wideband)	$I_C = 10\ \mu A$, $V_{CE} = 5V$, $R_S = 10k$, $P_{BW} = 15.7$ kHz		1.5	4	dB
h_{fe}	$I_C = 500\ \mu A$, $V_{CE} = 5V$, $f = 20$ MHz	3	6		
C_{ob}	$V_{CB} = 5V$, $f = 1$ MHz		1.7	3.0	pF
C_{eb}	$V_{EB} = 0.50V$, $f = 1$ MHz		5.5	8.0	pF
h_{FE}	$I_C = 1\ \mu A$, $V_{CE} = 5V$	35			
	$I_C = 10\ \mu A$, $V_{CE} = 5V$	50			
	$I_C = 100\ \mu A$, $V_{CE} = 5V$	70			
	$I_C = 500\ \mu A$, $V_{CE} = 5V$	80			
	$I_C = 1$ mA, $V_{CE} = 5V$	100	360	1000	
	$I_C = 20$ mA, $V_{CE} = 5V$	50			
$V_{CE(SAT)}$	$I_C = 1$ mA, $I_B = 0.10$ mA			0.10	V
	$I_C = 10$ mA, $I_B = 1$ mA			0.15	V
$V_{BE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.75	V
	$I_C = 10$ mA, $I_B = 1$ mA			0.85	V

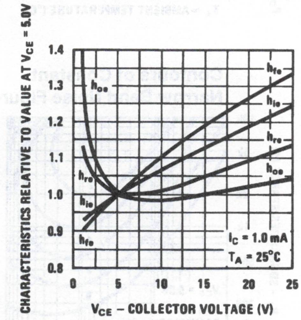
Process 07

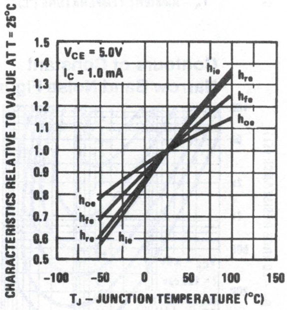
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1$ mA	60			V
BV_{CBO}	$I_C = 10\ \mu A$	60			V
BV_{EBO}	$I_E = 10\ \mu A$	8			V
I_{CBO}	$V_{CB} = 45V$			100	nA
I_{EBO}	$V_{EB} = 6V$			100	nA
$P_{D(max)}$					
TO-18	$T_A = 25°C$	600			mW
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW

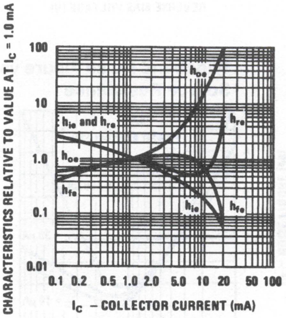
SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Parameter	Conditions	Typ	Units
h_{ie}	Input Resistance	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	15	kΩ
h_{oe}	Output Conductance	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	15	µmho
h_{re}	Voltage Feedback Ratio	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	425	$\times 10^{-6}$
h_{fe}	Small Signal Current Gain	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	400	
h_{ib}	Input Resistance	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	27	Ω

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

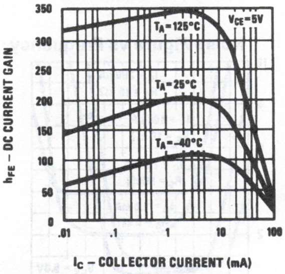




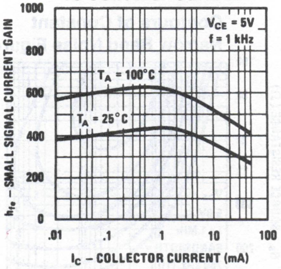


TL/G/10034-64

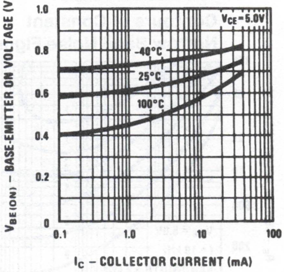
DC Current Gain vs Collector Current



Small Signal Current Gain vs Collector Current



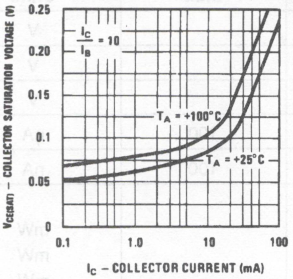
Base-Emitter ON Voltage vs Collector Current



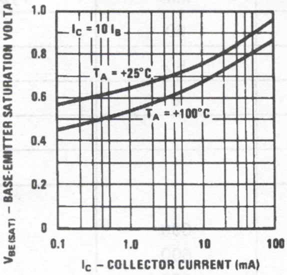
TL/G/10034-68

Process 07

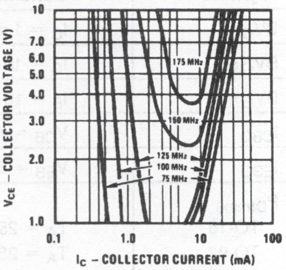
Collector Saturation Voltage vs Collector Current



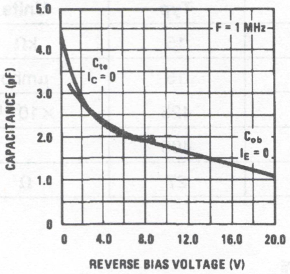
Base-Emitter Saturation Voltage vs Collector Current



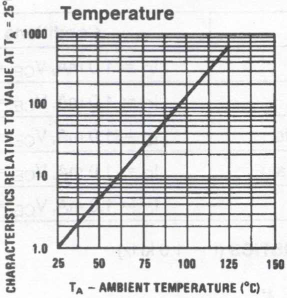
Contours of Constant Gain Bandwidth Product (f_T)



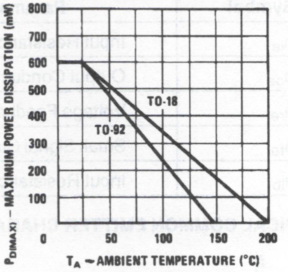
Input and Output Capacitance vs Reverse Bias Voltage



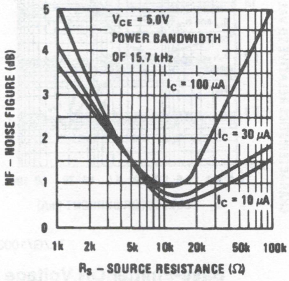
Normalized Collector Cutoff Current vs Ambient Temperature



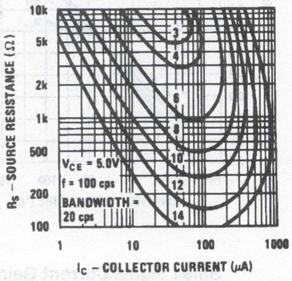
Maximum Power Dissipation vs Ambient Temperature



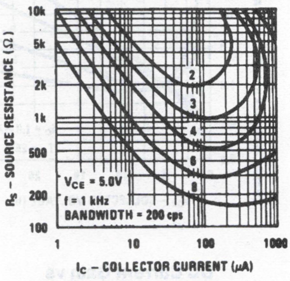
Wideband Noise Figure vs Source Resistance



Contours of Constant Narrow Band Noise Figure

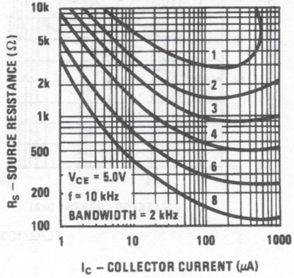


Contours of Constant Narrow Band Noise Figure

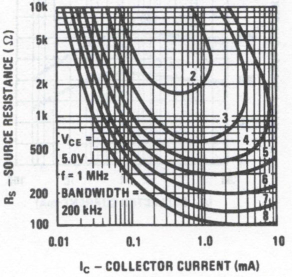


TL/G/10034–62

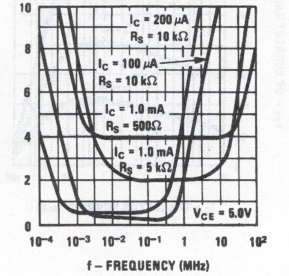
Contours of Constant Narrow Band Noise Figure



Contours of Constant Narrow Band Noise Figure



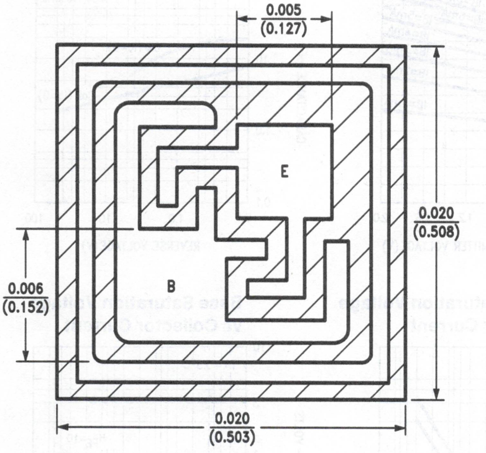
Noise Figure vs Frequency



TL/G/10034–63

National Semiconductor

Process 10
NPN Small Signal



TL/G/10034-65

DESCRIPTION

Process 10 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 68.

APPLICATION

This device was designed for general purpose amplifier applications at collector currents to 500 mA.

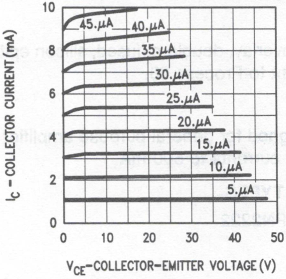
PRINCIPAL DEVICE TYPES

TO-92 EBC: PN100, PN2222
TO-92 ECB: 2N3415
TO-116: MPQ100
TO-236: MMBT100, 100A
16-SOIC: MMPQ100

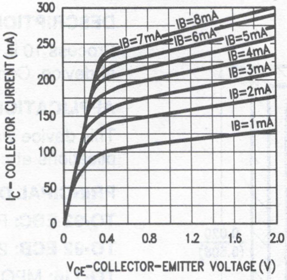
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CBO}	$I_C = 10\ \mu A$	75			V
BV_{CEO}	$I_C = 1\ mA$	45			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 60V$			50	nA
I_{CES}	$V_{CE} = 40V$			50	nA
I_{EBO}	$V_{EB} = 4V$			50	nA
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 1V$	80			
	$I_C = 10\ mA$, $V_{CE} = 1V$	100	250	600	
	$I_C = 100\ mA$, $V_{CE} = 1V$	100			
	$I_C = 150\ mA$, $V_{CE} = 5V$	100			
	$I_C = 300\ mA$, $V_{CE} = 5V$	60			
$V_{CE(s)}$	$I_C = 10\ mA$, $I_B = 1\ mA$			0.2	V
$V_{BE(s)}$	$I_C = 10\ mA$, $I_B = 1\ mA$			0.85	V
$V_{CE(s)}$	$I_C = 200\ mA$, $I_B = 20\ mA$			0.4	V
$V_{BE(s)}$	$I_C = 200\ mA$, $I_B = 20\ mA$			1.0	V
C_{ob}	$V_{CB} = 5V$, $f = 1\ MHz$		3.5	4.5	pF
f_T	$V_{CE} = 20V$, $I_C = 20\ mA$	200	300		MHz
t_s	$I_C = 10\ mA$, $I_{B_1} = I_{B_2} = 1\ mA$		275		ns
t_{OFF}	$I_C = 150\ mA$, $I_{B_1} = I_{B_2} = 15\ mA$		225		ns
NF	$I_C = 100\ \mu A$, $V_{CE} = 5V$, $R_G = 2\ k\Omega$, $f = 1\ kHz$		1.5		dB
$P_{D(max)}$					
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW

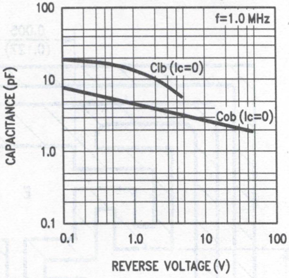
Process 10



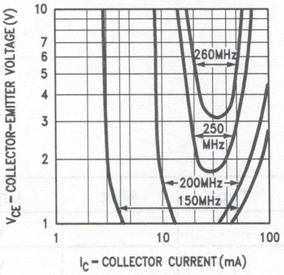
Collector Current vs Collector-Emitter Voltage



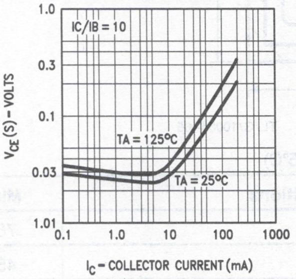
Collector Current vs Collector-Emitter Voltage



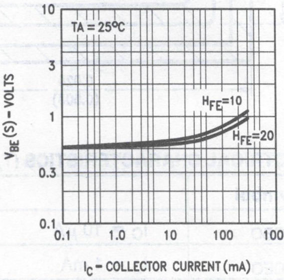
Input and Output Capacitance vs Reverse Voltage



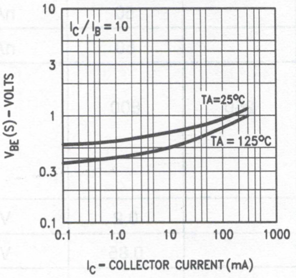
Contours of Constant Gain Bandwidth Product (FT)



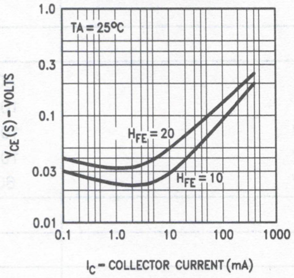
Collector Saturation Voltage vs Collector Current



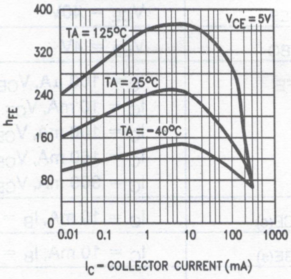
Base Saturation Voltage vs Collector Current



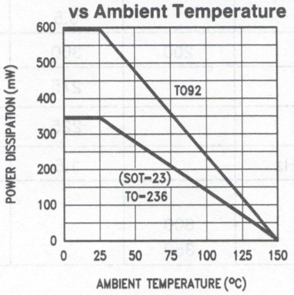
Base Saturation Voltage vs Collector Current



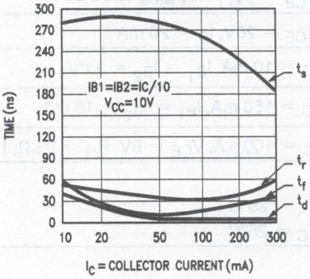
Collector Saturation Voltage vs Collector Current



D.C. Current Gain vs Collector Current



Total Power Dissipation vs Ambient Temperature

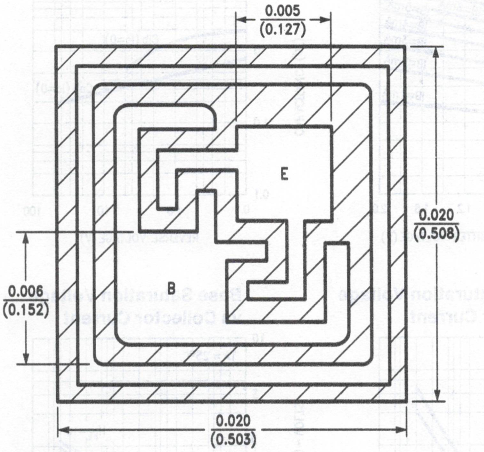


Switching Times vs Collector Current

TL/G/10034-7

National Semiconductor

Process 11
NPN Small Signal



TL/G/10034-8

DESCRIPTION

Process 11 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 69.

APPLICATION

This device was designed for general purpose amplifier applications at collector currents to 300 mA.

PRINCIPAL DEVICE TYPES

TO-92 EBC: PN101

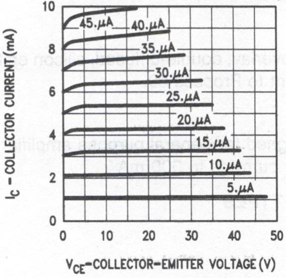
TO-236: MMBT101

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

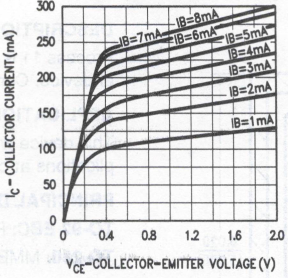
Symbol	Conditions	Min	Typ	Max	Units
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		3.0	4.0	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz		16	25	pF
NF	$I_C = 100\ \mu A$, $V_{CE} = 5V$ $R_S = 2\ k\Omega$, f = 1 kHz		2.0		dB
f_T	$V_{CE} = 10V$, $I_C = 20$ mA	150	250		MHz
h_{FE}	$V_{CE} = 1.0V$, $I_C = 1$ mA $V_{CE} = 1.0V$, $I_C = 100$ mA $V_{CE} = 1.0V$, $I_C = 150$ mA	40 100 75	 200 	 400 	
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.5	V
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			1.0	V
BV_{CBO}	$I_C = 10\ \mu A$	80			
BV_{CEO}	$I_C = 1$ mA	65			
BV_{EBO}	$I_E = 10\ \mu A$	6.0			
I_{CBO}	$V_{CB} = 60V$			50	nA
I_{CES}	$V_{CE} = 60V$			50	nA
I_{EBO}	$V_{EB} = 4.0V$			50	nA
$P_{D(max)}$ TO-92 TO-236	 $T_A = 25°C$ $T_C = 25°C$	 600 350			 mW mW

Process 11

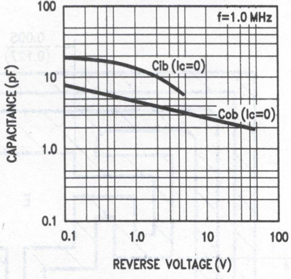
Collector Current vs Collector-Emitter Voltage



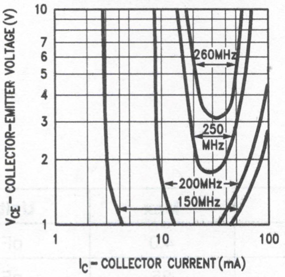
Collector Current vs Collector-Emitter Voltage



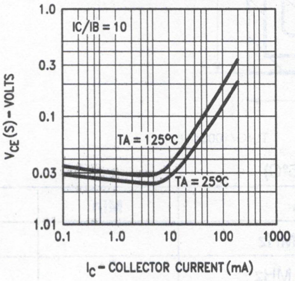
Input and Output Capacitance vs Reverse Voltage



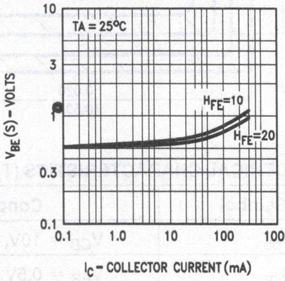
Contours of Constant Gain Bandwidth Product (FT)



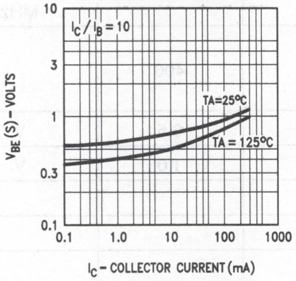
Collector Saturation Voltage vs Collector Current



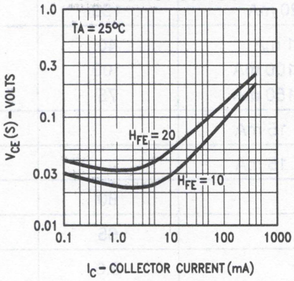
Base Saturation Voltage vs Collector Current



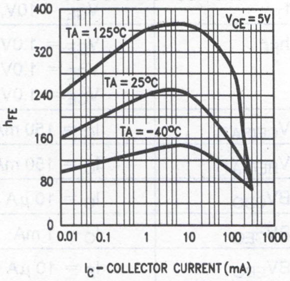
Base Saturation Voltage vs Collector Current



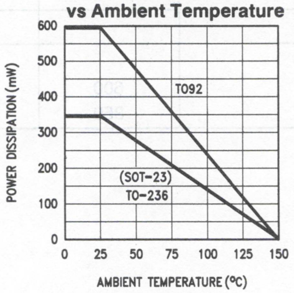
Collector Saturation Voltage vs Collector Current



D.C. Current Gain vs Collector Current



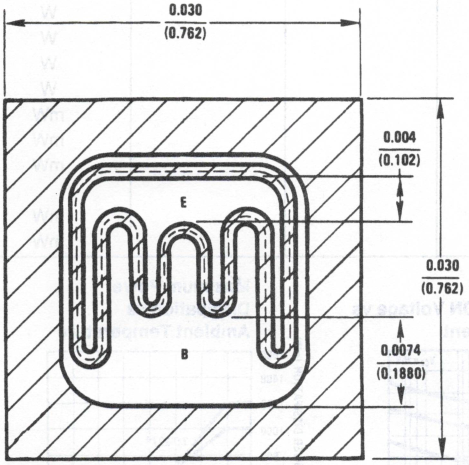
Total Power Dissipation vs Ambient Temperature



TL/G/10034–9

National Semiconductor

Process 12
NPN Medium Power



TL/G/10034-10

DESCRIPTION

Process 12 was a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 67.

APPLICATION

This device was designed for general purpose medium power amplifiers and switches requiring collector currents to 0.5A and collector voltages up to 80V.

PRINCIPAL DEVICE TYPES

TO-39 EBC: 2N3019
TO-92 EBC: MPSA06
TO-116: MPQA06
TO-202 EBC: NSDU06
TO-226 EBC: MPSW06
TO-236: MMBTA06
TO-237 EBC: TN3019

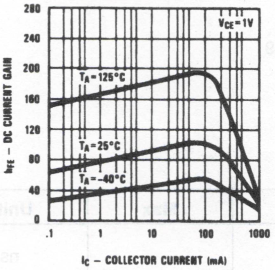
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	I_C = 150 mA, I_{B1} = 15 mA (*Figure 1*)		50		ns
t_{OFF}	I_C = 150 mA, I_{B2} = 15 mA (*Figure 1*)		400		ns
h_{fe}	I_C = 50 mA, V_{CE} = 10V, f = 20 MHz	4.0	6.5		
C_{ob}	V_{CB} = 10V, f = 1 MHz		6.5	10	pF
C_{eb}	V_{EB} = 0.5V, f = 1 MHz			60	pF
h_{FE}	I_C = 1 mA, V_{CE} = 10V I_C = 10 mA, V_{CE} = 10V I_C = 150 mA, V_{CE} = 10V I_C = 500 mA, V_{CE} = 10V	30 50 75 30	 175 	 350 	
$V_{CE(SAT)}$	I_C = 100 mA, I_B = 10 mA I_C = 500 mA, I_B = 50 mA			0.2 0.8	V V
$V_{BE(SAT)}$	I_C = 100 mA, I_B = 10 mA I_C = 500 mA, I_B = 50 mA			0.90 1.20	V V
BV_{CEO}	I_C = 10 mA	65			V
BV_{CBO}	I_C = 100 μA	100			V
BV_{EBO}	I_C = 10 μA	7			V
I_{CBO}	V_{CB} = 80V			100	nA
I_{EBO}	V_{EB} = 6V			100	nA

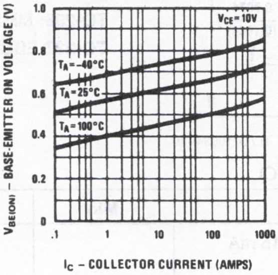
Process 12

Symbol	Conditions	Min	Typ	Max	Units
$P_{D(max)}$					
TO-202	$T_C = 25°C$	10			W
	$T_A = 25°C$	2			W
TO-39	$T_C = 25°C$	7			W
	$T_A = 25°C$	1			W
TO-226	$T_A = 25°C$	1			W
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW
TO-116	$T_A = 25°C$				
	(Total)	900			mW
	(Each Transistor)	500			mW

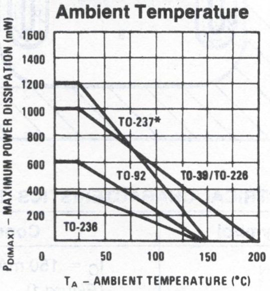
DC Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current



Maximum Power Dissipation vs Ambient Temperature



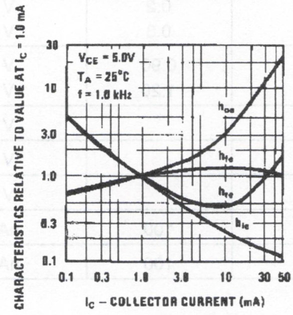
* One square inch of copper run

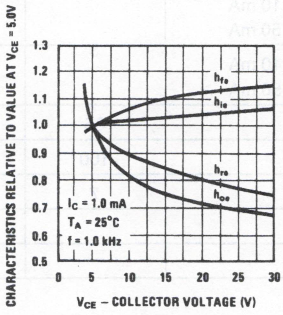
TL/G/10034–11

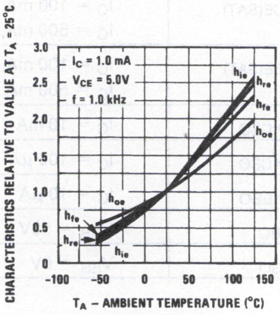
SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Parameter	Conditions	Typ	Units
h_{je}	Input Resistance	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	3000	Ω
h_{oe}	Output Conductance	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	8.0	µmhos
h_{re}	Voltage Feedback Ratio	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	2.1	$\times 10^{-4}$
h_{fe}	Small Signal Current Gain	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	100	

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)



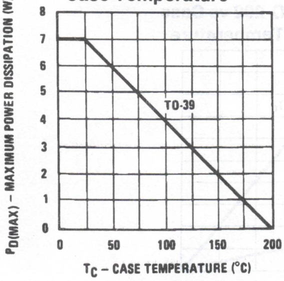




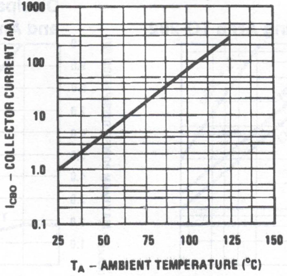
TL/G/10034–15

Process 12

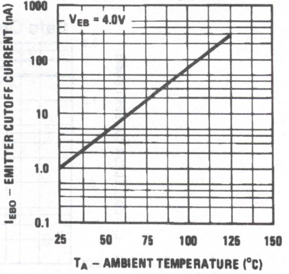
Maximum Power Dissipation vs Case Temperature



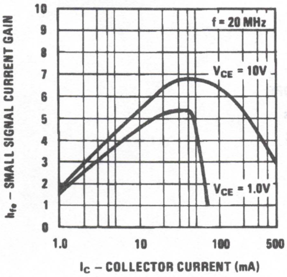
Collector Reverse Current vs Ambient Temperature



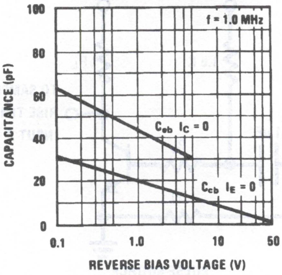
Emitter Cutoff Current vs Ambient Temperature



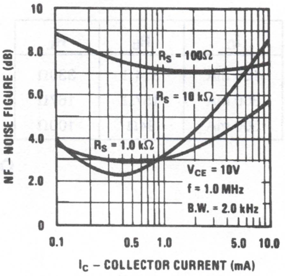
Small Signal Current Gain at 20 MHz



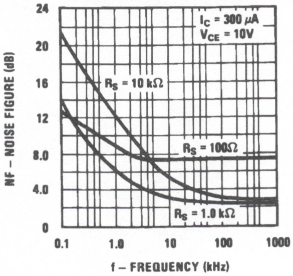
Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage



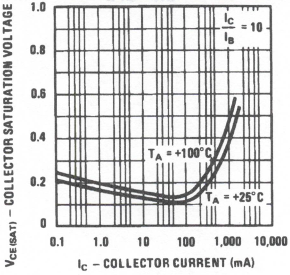
Noise Figure vs Collector Current



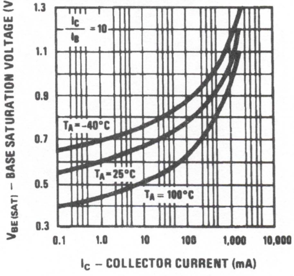
Noise Figure vs Frequency



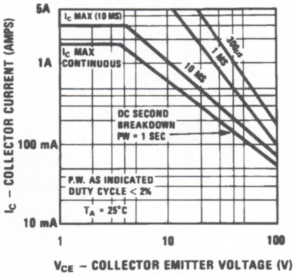
Collector Saturation Voltage vs Collector Current



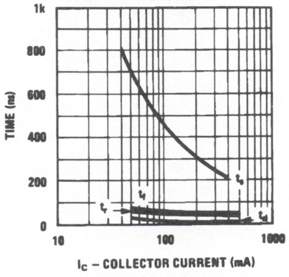
Base Saturation Voltage vs Collector Current



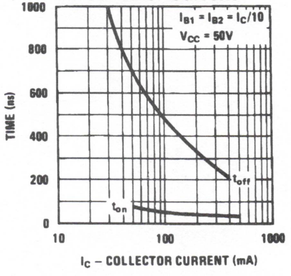
Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink



Switching Times vs Collector Current



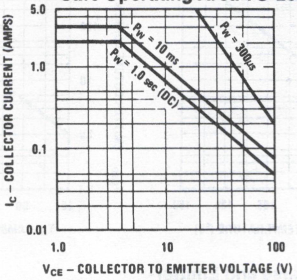
Turn On and Turn Off Times vs Collector Current



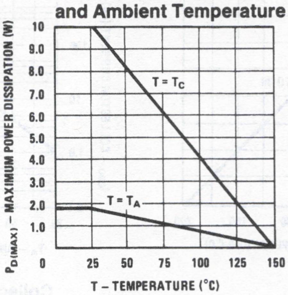
TL/G/10034–12

Process 12

Safe Operating Area TO-202

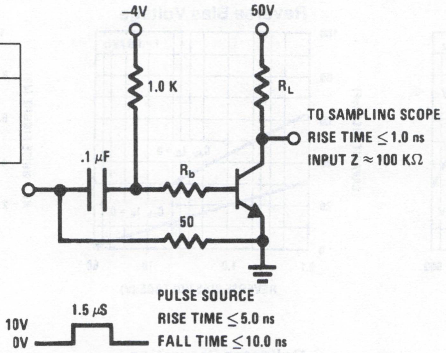


Maximum Power Dissipation TO-202 vs Case and Ambient Temperature



TL/G/10034-13

I_C	R_b	R_L
150 mA	314Ω	330Ω
300 mA	157Ω	167Ω
500 mA	94Ω	100Ω

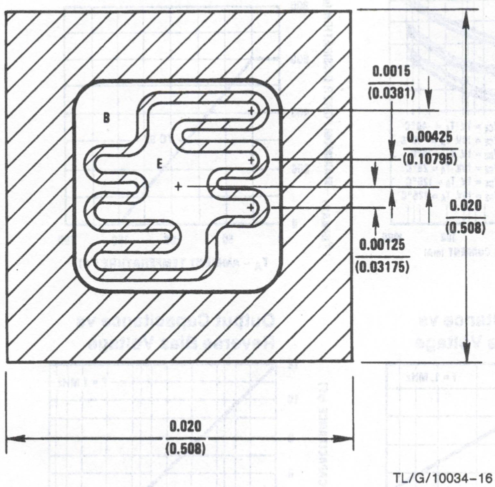

−4V
50V
1.0 K
R_L
TO SAMPLING SCOPE
RISE TIME ≤1.0 ns
INPUT Z ≈ 100 KΩ
.1 µF
R_b
50
1.5 µS
10V
0V
PULSE SOURCE
RISE TIME ≤5.0 ns
FALL TIME ≤10.0 ns

TL/G/10034-14

FIGURE 1. t_{ON}, t_{OFF} Test Circuit

National Semiconductor

Process 13
NPN Medium Power



TL/G/10034-16

DESCRIPTION

Process 13 is a non-overlay, double-diffused, silicon epitaxial device.

APPLICATION

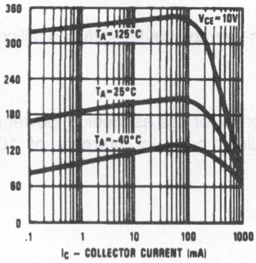
This device is designed for use as medium power amplifiers and switches requiring collector currents of 100 μA to 500 mA.

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

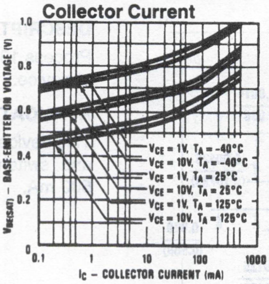
Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	I_C = 150 mA, I_{B1} = 15 mA		35		ns
t_{OFF}	I_C = 150 mA, I_{B2} = 15 mA		250		ns
h_{fe}	I_C = 20 mA, V_{CE} = 20V, f = 100 MHz	2.0	3.0		
NF (spot)	I_C = 100 μA, V_{CE} = 10V, R_S = 1 kΩ, f = 1 kHz		2.0		dB
C_{ob}	V_{CB} = 10V, f = 1 MHz		4.5	8.0	pF
C_{ib}	V_{EB} = 0.5V, f = 1 MHz			35	pF
h_{FE}	V_{CE} = 1.0V, I_C = 1.0 mA V_{CE} = 1.0V, I_C = 10 mA V_{CE} = 1.0V, I_C = 100 mA V_{CE} = 1.0V, I_C = 500 mA	30 40 50 25	 150 	 300 	
$V_{CE(SAT)}$	I_C = 150 mA, I_B = 15 mA I_C = 500 mA, I_B = 50 mA			0.2 0.5	V V
$V_{BE(SAT)}$	I_C = 150 mA, I_B = 15 mA I_C = 500 mA, I_B = 50 mA			1.0 1.2	V V
BV_{CBO}	I_C = 100 μA	60			V
BV_{CEO}	I_C = 10 mA	35			V
BV_{EBO}	I_C = 10 μA	6.0			V
I_{CBO}	V_{CB} = 40V			100	nA
I_{EBO}	V_{EB} = 4V			100	nA

Process 13

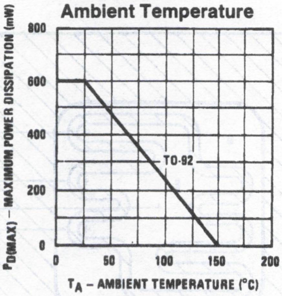
DC Current Gain vs Collector Current



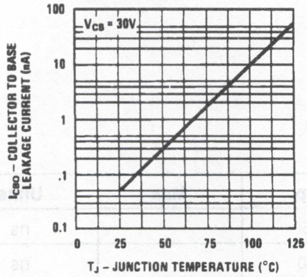
Base-Emitter ON Voltage vs Collector Current



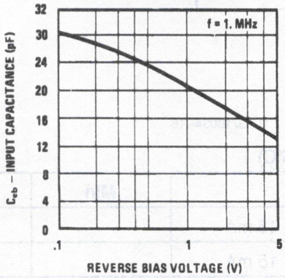
Maximum Power Dissipation vs Ambient Temperature



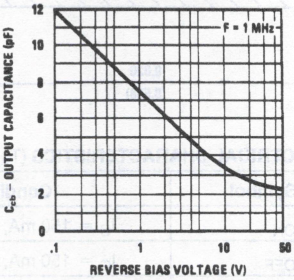
Collector-Base Diode Reverse Current vs Temperature



Input Capacitance vs Reverse Bias Voltage

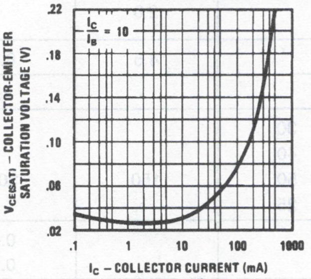


Output Capacitance vs Reverse Bias Voltage

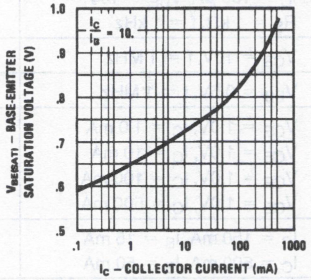


TL/G/10034–17

Collector-Emitter Saturation Voltage vs Collector Current



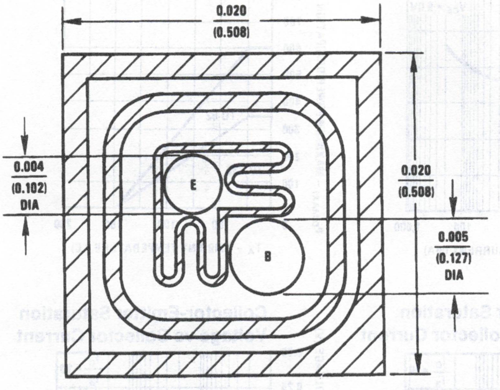
Base-Emitter Saturation Voltage vs Collector Current



TL/G/10034–18

National Semiconductor

Process 16
NPN High Voltage



TL/G/10034-19

DESCRIPTION

Process 16 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 74.

APPLICATION

This device was designed for general purpose high voltage amplifiers and gas discharge display driving.

PRINCIPAL DEVICE TYPES

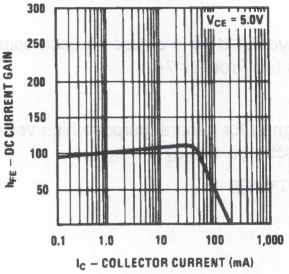
TO-92 EBC: 2N5551

TO-236: MMBT5551

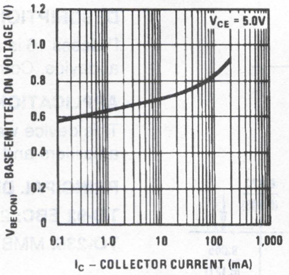
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1.0$ mA	120			V
BV_{CBO}	$I_C = 10\ \mu A$	140			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 100V$			100	nA
I_{EBO}	$V_{EB} = 4.0V$			100	nA
h_{FE}	$I_C = 1.0$ mA, $V_{CE} = 5.0V$	40			
	$I_C = 10$ mA, $V_{CE} = 5.0V$	50	120	300	
	$I_C = 50$ mA, $V_{CE} = 5.0V$	20			
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1.0$ mA			0.15	V
	$I_C = 50$ mA, $I_B = 5.0$ mA			0.30	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1.0$ mA			0.90	V
	$I_C = 50$ mA, $I_B = 5$ mA			1.2	V
f_T	$I_C = 10$ mA, $V_{CE} = 10V$, f = 100 MHz	100	220		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		3.0	5.0	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			30	pF
$P_{D(max)}$					
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW

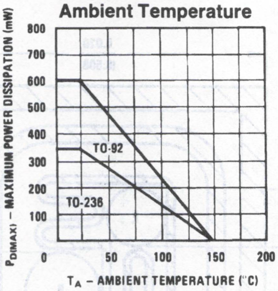
DC Current Gain vs Collector Current



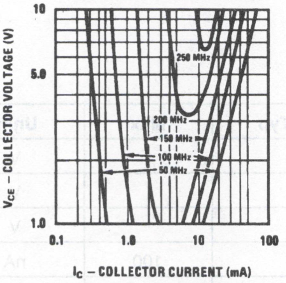
Base-Emitter ON Voltage vs Collector Current



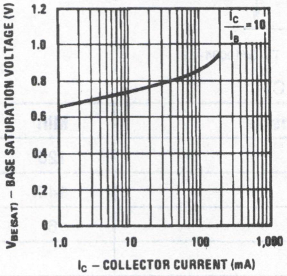
Maximum Power Dissipation vs Ambient Temperature



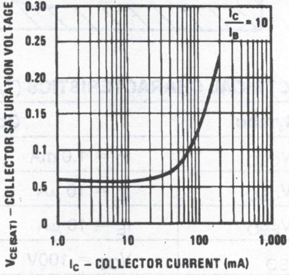
Contours of Constant Gain Bandwidth Product (f_T)



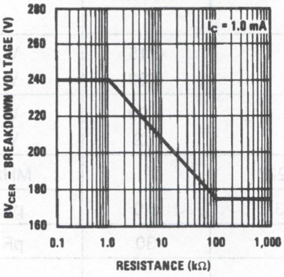
Base-Emitter Saturation Voltage vs Collector Current



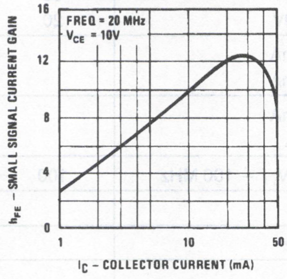
Collector-Emitter Saturation Voltage vs Collector Current



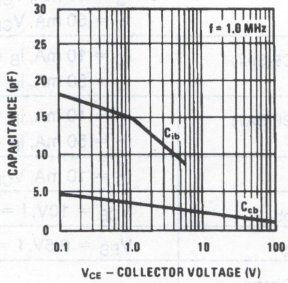
Collector-Emitter Breakdown Voltage with Resistance Between Emitter-Base



Small Signal Current Gain vs Collector Current



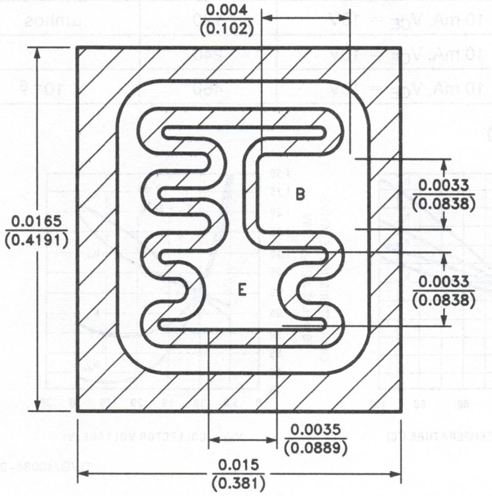
Input and Output Capacitance vs Reverse Bias Voltage



TL/G/10034-20

National Semiconductor

Process 19
NPN General Purpose Amplifier



TL/G/10034-21

DESCRIPTION

Process 19 is a non-overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 63.

APPLICATION

This device was designed for use as a medium power amplifier and switch requiring collector currents up to 500 mA.

PRINCIPAL DEVICE TYPES

TO-5 EBC: 2N2219, 2219A
TO-18 EBC: 2N2222, 2222A
TO-92 EBC: PN2222A, 2N4401
TO-116: MPQ2222
TO-236: MMBT2222
16-SOIC: MMPQ2222

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

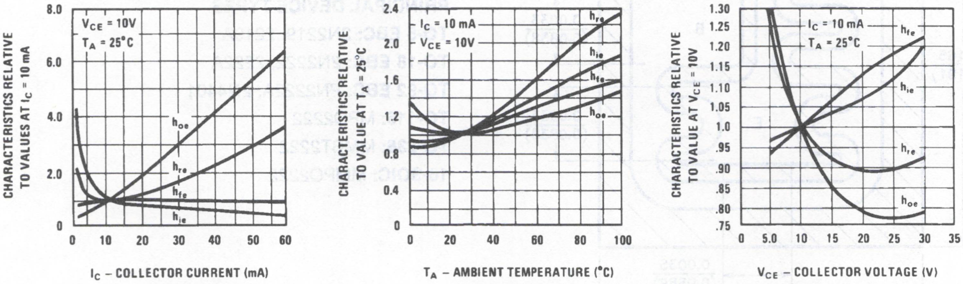
Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	$I_C = 150$ mA, $I_{B1} = 15$ mA		25	35	ns
t_{OFF}	$I_C = 150$ mA, $I_{B2} = 15$ mA		200	285	ns
h_{fe}	$I_C = 20$ mA, $V_{CE} = 20V$, f = 100 MHz	2.0	3.5		
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		4.0	6.0	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			25	pF
NF (spot)	$I_C = 100\ \mu A$, $V_{CE} = 10V$, $R_S = 1\ k\Omega$, f = 1 kHz		2.0		dB
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 10V$ $I_C = 1$ mA, $V_{CE} = 10V$ $I_C = 10$ mA, $V_{CE} = 10V$ $I_C = 150$ mA, $V_{CE} = 10V$ $I_C = 500$ mA, $V_{CE} = 10V$	30 40 50 60 30	 180 	 420 	
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA $I_C = 500$ mA, $I_B = 50$ mA			0.50 1.0	V V
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA $I_C = 500$ mA, $I_B = 50$ mA			1.2 1.5	V V
BV_{CEO}	$I_C = 10$ mA	35			V
BV_{CBO}	$I_C = 100\ \mu A$	60			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 40V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA

Process 19

SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

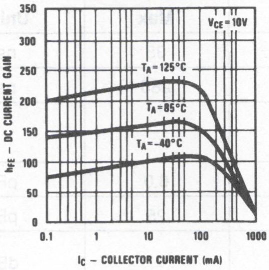
Symbol	Parameter	Conditions	Typ	Units
h_{ie}	Input Resistance	$I_C = 10$ mA, $V_{CE} = 10V$	700	Ω
h_{oe}	Output Conductance	$I_C = 10$ mA, $V_{CE} = 10V$	120	μmhos
h_{fe}	Small Signal Current Gain	$I_C = 10$ mA, $V_{CE} = 10V$	240	
h_{re}	Voltage Feedback Ratio	$I_C = 10$ mA, $V_{CE} = 10V$	460	$\times 10^{-6}$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

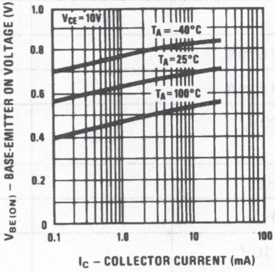


TL/G/10034-24

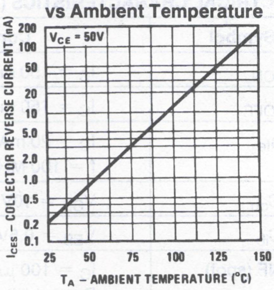
DC Current Gain vs Collector Current



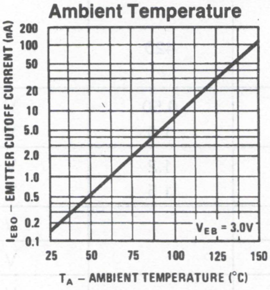
Base-Emitter ON Voltage vs Collector Current



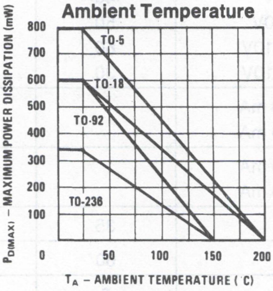
Collector Reverse Current vs Ambient Temperature



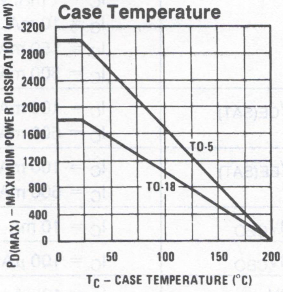
Emitter Cutoff Current vs Ambient Temperature



Maximum Power Dissipation vs Ambient Temperature



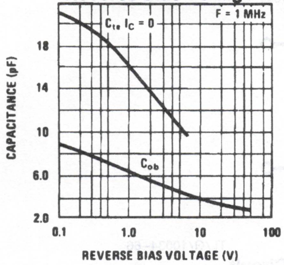
Maximum Power Dissipation vs Case Temperature



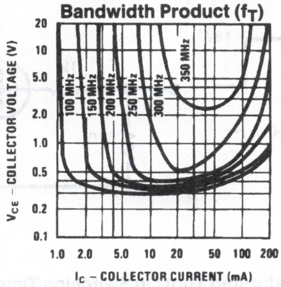
TL/G/10034-22

Process 19

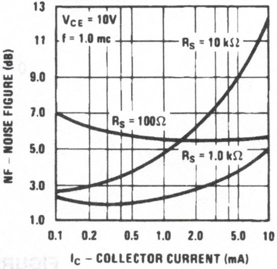
Emitter Transition and Output Capacitance vs Reverse Bias Voltage



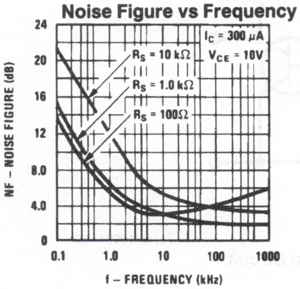
Contours of Constant Gain Bandwidth Product (f_T)



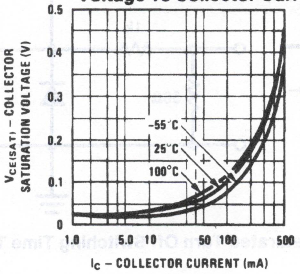
Noise Figure vs Collector Current



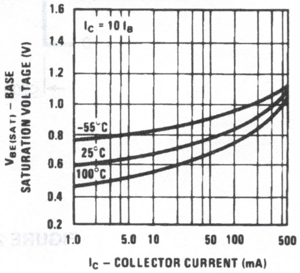
Noise Figure vs Frequency



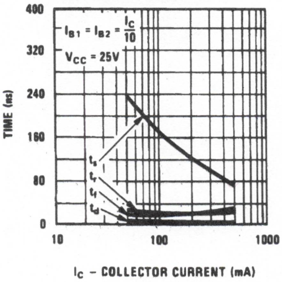
Collector Saturation Voltage vs Collector Current



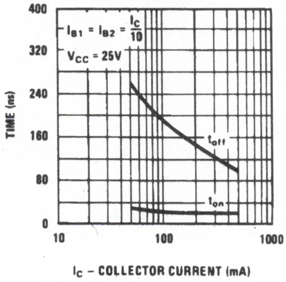
Base Saturation Voltage vs Collector Current



Switching Time vs Collector Current

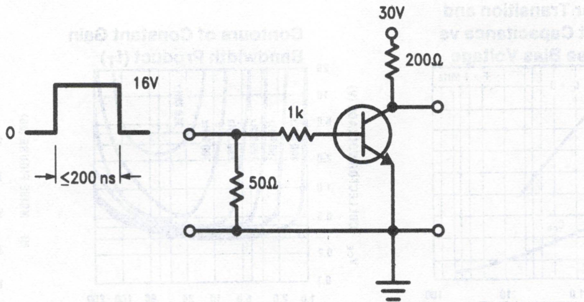


Turn On and Turn Off Times vs Collector Current



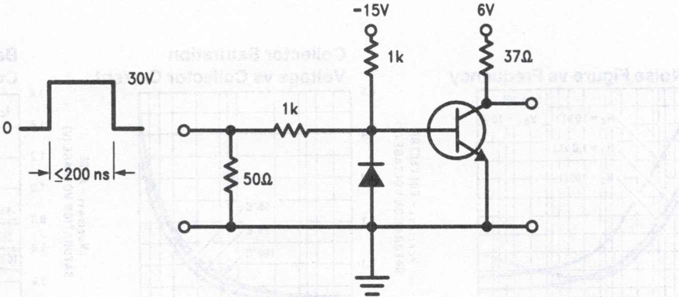
TL/G/10034-23

Process 19


30V
200Ω
16V
0
1k
≤200 ns
50Ω

TL/G/10034-66

FIGURE 1. Saturated Turn On Switching Time Test Circuit

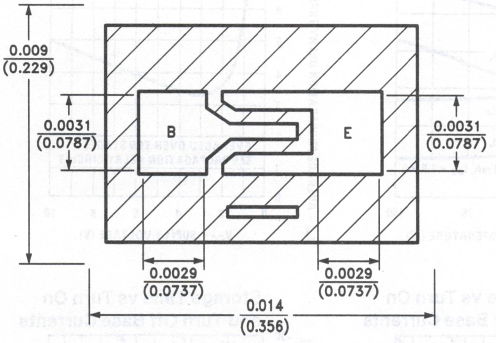

−15V
6V
1k
37Ω
30V
0
1k
≤200 ns
50Ω

TL/G/10034-67

FIGURE 2. Saturated Turn Off Switching Time Test Circuit

National Semiconductor

Process 21
NPN High Speed Switch



TL/G/10034–25

DESCRIPTION

Process 21 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 65.

APPLICATION

This device was designed for high speed saturated switching at collector currents of 10 mA to 100 mA.

PRINCIPAL DEVICE TYPES

TO-18 EBC: 2N2369, 2N2369A

TO-92 EBC: PN2369

TO-236: MMBT2369

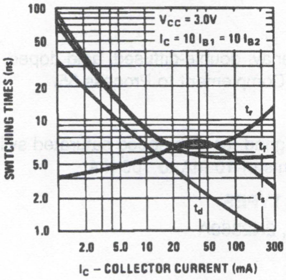
16-SOIC: MMPQ2369

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

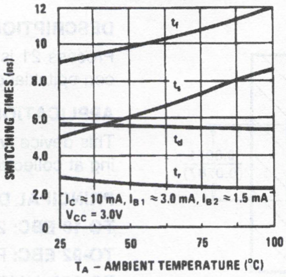
Symbol	Conditions	Min	Typ	Max	Units
t_s	$I_{B1} = I_{B2} = I_C$ = 10 mA *(Figure 1)*		7	13	ns
t_{ON}	I_C = 10 mA, I_{B1} = 3 mA *(Figure 2)*		9	12	ns
t_{OFF}	I_C = 10 mA, I_{B2} = 1.50 mA *(Figure 2)*		12	20	ns
h_{fe}	I_C = 10 mA, V_{CE} = 10V, f = 100 MHz	4.5	6.5		
C_{ob}	V_{CB} = 5V, f = 1 MHz		2.0	4.0	pF
C_{ib}	V_{EB} = 0.5V, f = 1 MHz			5.0	pF
h_{FE}	I_C = 1 mA, V_{CE} = 1V	30			
	I_C = 10 mA, V_{CE} = 1V	35	70	150	
	I_C = 50 mA, V_{CE} = 1V	30	55	150	
	I_C = 100 mA, V_{CE} = 1V	20			
	I_C = 10 mA, V_{CE} = 0.35V	30			
	I_C = 30 mA, V_{CE} = 0.4V	30			
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 1 mA			0.2	V
	I_C = 100 mA, I_B = 10 mA			0.5	V
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 1 mA			0.85	V
	I_C = 100 mA, I_B = 10 mA			1.5	V
BV_{CEO}	I_C = 10 mA	12			V
BV_{CBO}	I_C = 10 μA	30			V
BV_{EBO}	I_E = 10 μA	4.5			V
I_{CBO}	V_{CB} = 20V			100	nA
I_{EBO}	V_{EB} = 3V			100	nA
$P_{D(max)}$					
TO-18	T_A = 25°C	600			mW
TO-92	T_A = 25°C	600			mW
TO-236	T_A = 25°C	350			mW

Process 21

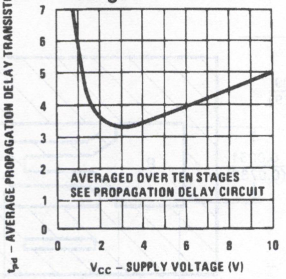
Switching Times vs Collector Current



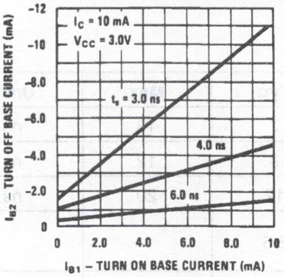
Switching Times vs Ambient Temperature



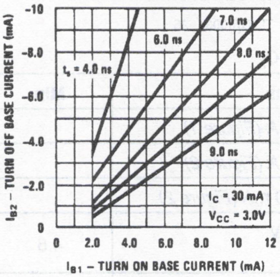
Average Propagation Delay per Transistor vs Collector Voltage



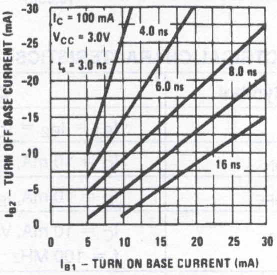
Storage Time vs Turn On and Turn Off Base Currents



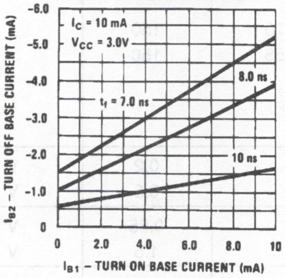
Storage Time vs Turn On and Turn Off Base Currents



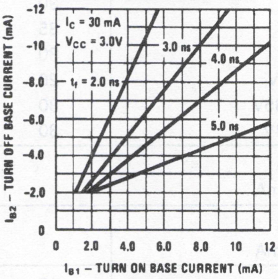
Storage Time vs Turn On and Turn Off Base Currents



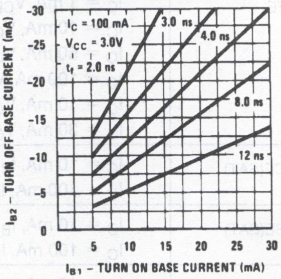
Fall Time vs Turn On and Turn Off Base Current



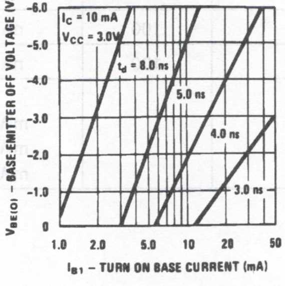
Fall Time vs Turn On and Turn Off Base Current



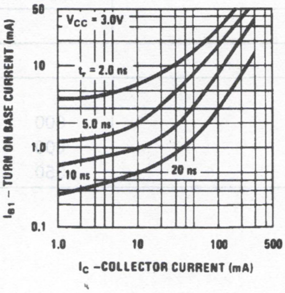
Fall Time vs Turn On and Turn Off Base Current



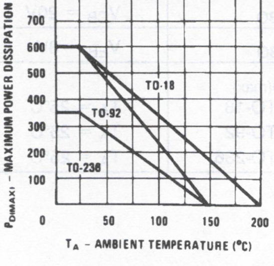
Delay Time vs Base-Emitter Off Voltage and Turn On Base Current



Rise Time vs Turn On Base Current and Collector Current



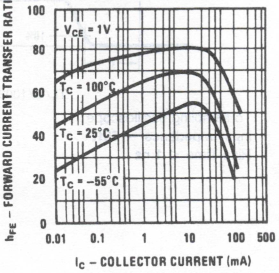
Maximum Power Dissipation vs Ambient Temperature



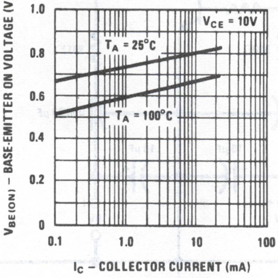
TL/G/10034-26

Process 21

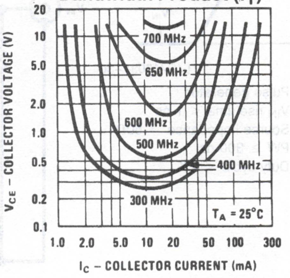
DC Current Gain vs Collector Current



Base-Emitter On Voltage vs Collector Current

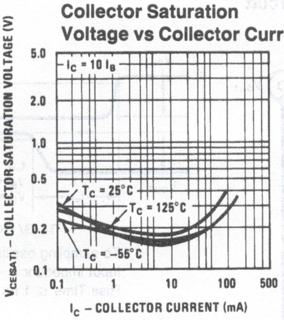


Contours of Constant Gain Bandwidth Product (f_T)

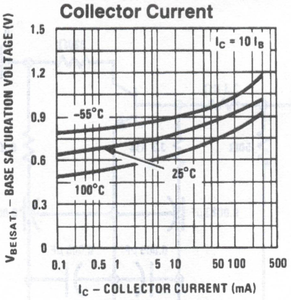


TL/G/10034-27

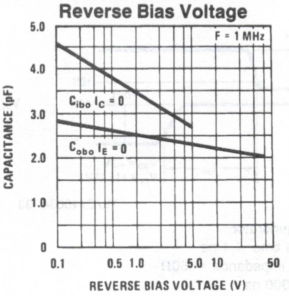
Collector Saturation Voltage vs Collector Current



Base Saturation Voltage vs Collector Current

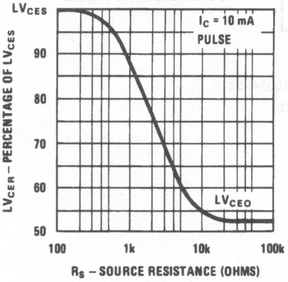


Emitter Transition and Output Capacitances vs Reverse Bias Voltage

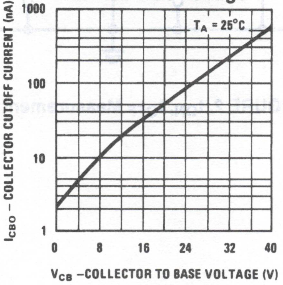


TL/G/10034-28

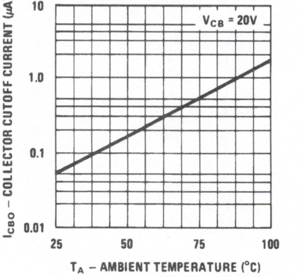
Lower Limiting Voltage vs Source Resistance



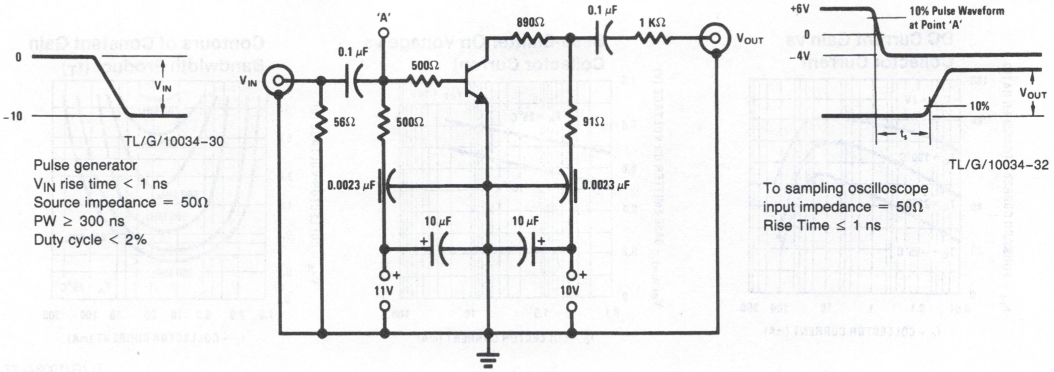
Collector Cutoff Current vs Reverse Bias Voltage



Collector Cutoff Current vs Ambient Temperature



TL/G/10034-29

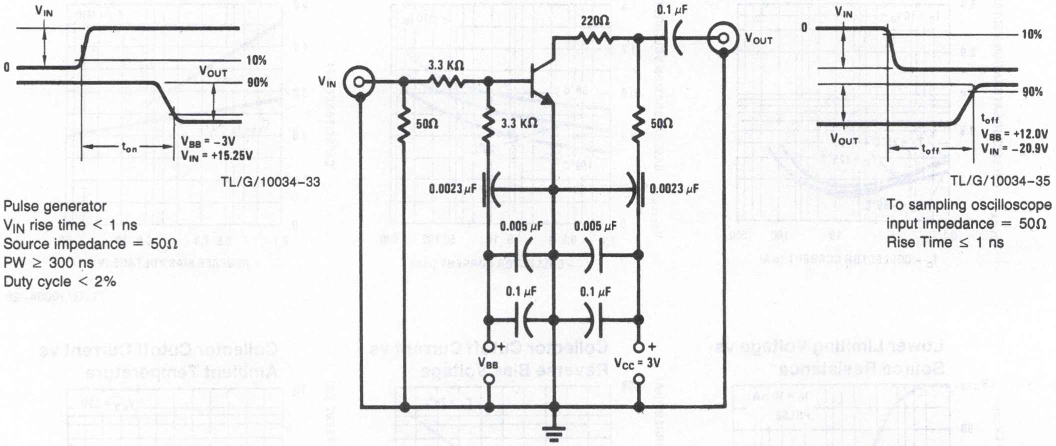

0
-10
V_{IN}
TL/G/10034-30
'A'
0.1 µF
890Ω
0.1 µF
1 KΩ
V_{OUT}
V_{IN}
500Ω
56Ω
500Ω
91Ω
0.0023 µF
0.0023 µF
10 µF
10 µF
+
+
11V
10V
+6V
10% Pulse Waveform at Point 'A'
0
-4V
V_{OUT}
10%
t_s
TL/G/10034-32

Pulse generator
V_{IN} rise time < 1 ns
Source impedance = 50Ω
PW ≥ 300 ns
Duty cycle < 2%

To sampling oscilloscope
input impedance = 50Ω
Rise Time ≤ 1 ns

TL/G/10034-31

FIGURE 1. Charge Storage Time Measurement Circuit


V_{IN}
0
V_{OUT}
10%
90%
t_{on}
$V_{BB} = -3V$
$V_{IN} = +15.25V$
TL/G/10034-33
0.1 µF
220Ω
V_{OUT}
3.3 KΩ
V_{IN}
50Ω
3.3 KΩ
50Ω
0.0023 µF
0.0023 µF
0.005 µF
0.005 µF
0.1 µF
0.1 µF
+
+
V_{BB}
$V_{CC} = 3V$
V_{IN}
0
10%
90%
V_{OUT}
t_{off}
t_{off}
$V_{BB} = +12.0V$
$V_{IN} = -20.9V$
TL/G/10034-35

Pulse generator
V_{IN} rise time < 1 ns
Source impedance = 50Ω
PW ≥ 300 ns
Duty cycle < 2%

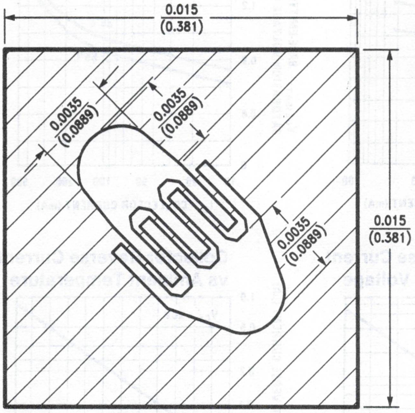
To sampling oscilloscope
input impedance = 50Ω
Rise Time ≤ 1 ns

TL/G/10034-34

FIGURE 2. t_{ON}, t_{OFF} Measurement Circuit

National Semiconductor

Process 22
NPN High Speed Switch



TL/G/10034-38

DESCRIPTION

Process 22 is an overlay, double-diffused, gold doped, silicon epitaxial device.

APPLICATION

This device was designed for high speed logic and core driver applications to 300 mA.

PRINCIPAL DEVICE TYPES

TO-52 EBC: 2N3013

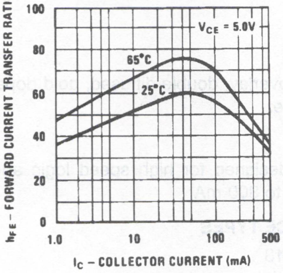
TO-92 EBC: 2N5772, PN3646

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

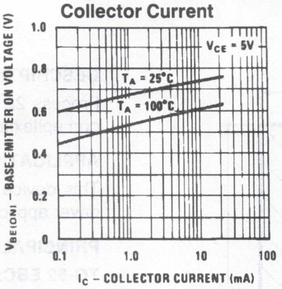
Symbol	Conditions	Min	Typ	Max	Units
t_s	I_C = 10 mA, I_{B1} = I_{B2} = 10 mA *(Figure 1)*		12	18	ns
t_{ON}	I_C = 300 mA, I_{B1} = I_{B2} = 30 mA *(Figure 2)*		10	18	ns
t_{OFF}	I_C = 300 mA, I_{B1} = I_{B2} = 30 mA		18	30	ns
C_{ob}	V_{CB} = 5V, f = 1 MHz		3.0	5.0	pF
C_{ib}	V_{EB} = 0.5V, f = 1 MHz			8.0	pF
h_{fe}	I_C = 30 mA, V_{CE} = 10V, f = 100 MHz	3.5	7.0		
h_{FE}	V_{CE} = 1V, 10 mA	20			
	V_{CE} = 1V, I_C = 30 mA	25	60	150	
	V_{CE} = 1V, I_C = 100 mA	20	45	150	
	V_{CE} = 1V, I_C = 300 mA	15			
	V_{CE} = 0.4V, I_C = 30 mA	20			
	V_{CE} = 0.5V, I_C = 100 mA	20			
$V_{CE(SAT)}$	I_C = 30 mA, I_B = 3 mA			0.20	V
	I_C = 100 mA, I_B = 10 mA			0.30	V
	I_C = 300 mA, I_B = 30 mA			0.50	V
$V_{BE(SAT)}$	I_C = 30 mA, I_B = 3 mA			0.95	V
	I_C = 100 mA, I_B = 10 mA			1.2	V
	I_C = 300 mA, I_B = 30 mA			1.7	V
BV_{CBO}	I_C = 10 μA	35			V
BV_{CEO}	I_C = 10 mA	15			V
BV_{EBO}	I_E = 10 μA	5.0			V
I_{CBO}	V_{CB} = 25V			100	nA
I_{EBO}	V_{EB} = 3V			100	nA

Process 22

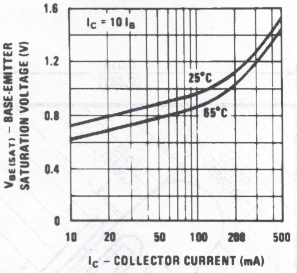
DC Current Gain vs Collector Current



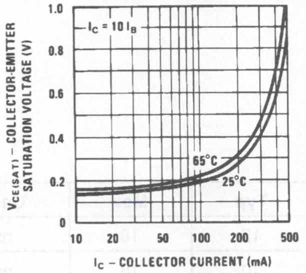
Base-Emitter On Voltage vs Collector Current



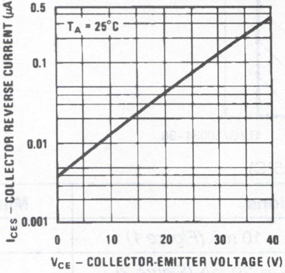
Base Saturation Voltage vs Collector Current



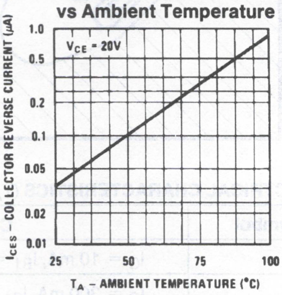
Collector Saturation Voltage vs Collector Current



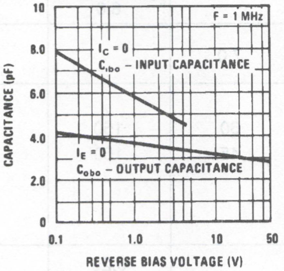
Collector Reverse Current vs Reverse Bias Voltage



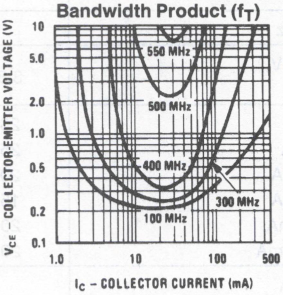
Collector Reverse Current vs Ambient Temperature



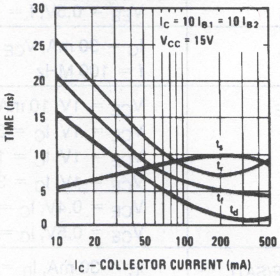
Input and Output Capacitance vs Reverse Bias Voltage



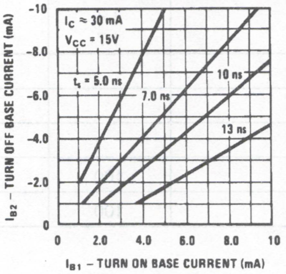
Contours of Constant Gain Bandwidth Product (f_T)



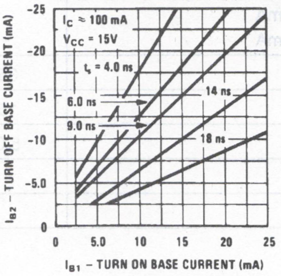
Switching Times vs Collector Current



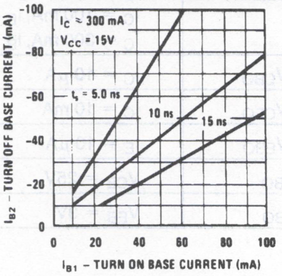
Storage Time vs Turn On and Turn Off Base Currents



Storage Time vs Turn On and Turn Off Base Currents

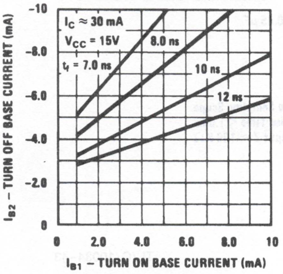


Storage Time vs Turn On and Turn Off Base Currents

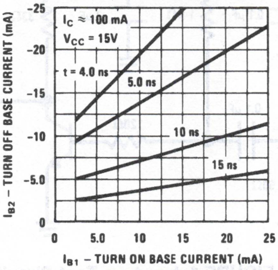


TL/G/10034-39

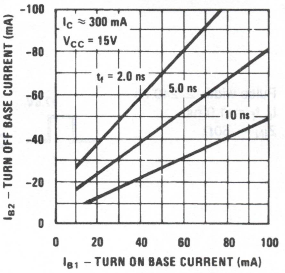
Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents

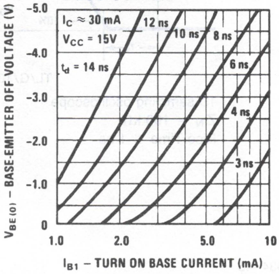


Fall Time vs Turn On and Turn Off Base Currents

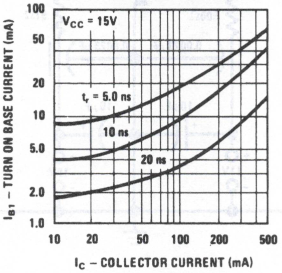


TL/G/10034–40

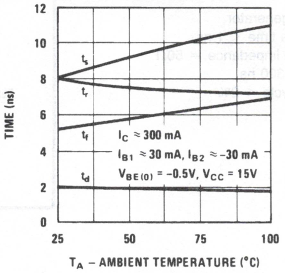
Delay Time vs Base-Emitter Off Voltage and Turn On Base Current



Rise Time vs Collector and Turn Off Base Currents

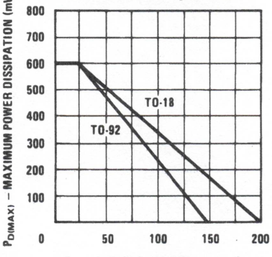


Switching Time vs Ambient Temperature



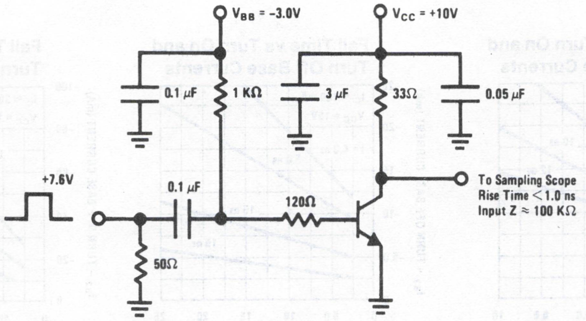
TL/G/10034–41

Maximum Power Dissipation vs Ambient Temperature



TL/G/10034–42

Process 22

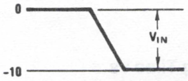


V_BB = -3.0V
V_CC = +10V
0.1 μF
1 KΩ
3 μF
33Ω
0.05 μF
+7.6V
0.1 μF
120Ω
50Ω
To Sampling Scope
Rise Time < 1.0 ns
Input Z ≈ 100 KΩ

Pulse width ≥ 240 ns
t_r, t_f = 1.0 ns
Z_{IN} = 50Ω

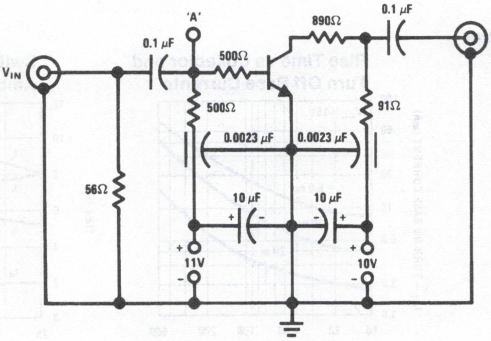
TL/G/10034-43

FIGURE 1. t_{ON}, t_{OFF} Test Circuit

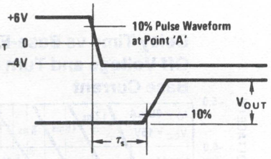


TL/G/10034-44

Pulse generator
V_{IN} rise time < 1 ns
Source impedance = 50Ω
PW ≥ 300 ns
Duty cycle < 2%



'A'
0.1 μF
890Ω
0.1 μF
500Ω
V_IN
V_OUT
500Ω
91Ω
0.0023 μF
0.0023 μF
56Ω
10 μF
10 μF
+
-
11V
10V



+6V
0
-4V
10% Pulse Waveform at Point 'A'
V_OUT
10%
T_s

TL/G/10034-46

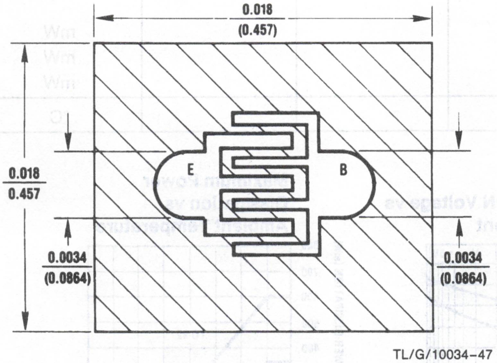
To sampling oscilloscope
Z_{IN} = 100 kΩ
Rise Time ≤ 1 ns

TL/G/10034-45

FIGURE 2. Charge Storage Time Measurement Circuit

National Semiconductor

Process 23
NPN Small Signal



TL/G/10034–47

DESCRIPTION

Process 23 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 66.

APPLICATION

This device is designed as a general purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.

PRINCIPAL DEVICE TYPES

TO-92 EBC: 2N3904, 2N4124

TO-236: MMBT3904, MMBT4124

TO-116: MPQ3904

16-SOIC: MMPQ3904

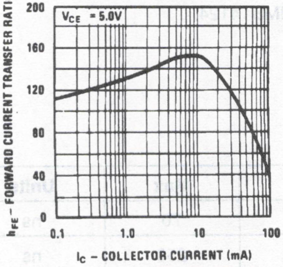
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	$I_C = 10$ mA, $I_{B1} = 1$ mA *(Figure 1)*		30	70	ns
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1$ mA *(Figure 2)*		150	250	ns
C_{ob}	$V_{CB} = 5V$, f = 1 MHz		2.7	4.0	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			8.0	pF
NF	$V_{CE} = 5V$, $I_C = 100\ \mu A$, $R_S = 1\ k\Omega$, $P_{BW} = 15.7$ kHz		2.0		dB
h_{fe}	$I_C = 10$ mA, $V_{CE} = 20V$, f = 100 MHz	2.5	4.5		
h_{FE}	$I_C = 100\ \mu A$, $V_{CE} = 5V$	40			
	$I_C = 1$ mA, $V_{CE} = 5V$	90			
	$I_C = 10$ mA, $V_{CE} = 5V$	60	150	360	
	$I_C = 50$ mA, $V_{CE} = 5V$	40			
	$I_C = 100$ mA, $V_{CE} = 5V$	20			
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.15	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.80	V
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.25	V
$V_{BE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.85	V
BV_{CBO}	$I_C = 10\ \mu A$	60			V
BV_{CEO}	$I_C = 1$ mA	30			V
BV_{EBO}	$I_E = 10\ \mu A$	6.0			V
I_{CBO}	$V_{CB} = 30V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA

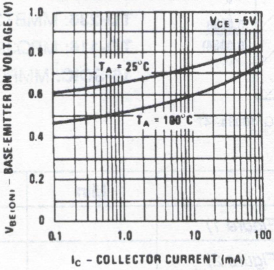
Process 23

Symbol	Conditions	Min	Typ	Max	Units
$P_{D(max)}$					
TO-92	$T_A = 25°C$	600			mW
TO-116	$T_A = 25°C$				
	(Total)	900			mW
	(Each Transistor)	500			mW
TO-236	$T_C = 25°C$	350			mW
$T_{j(max)}$	All Plastic Parts	150			°C

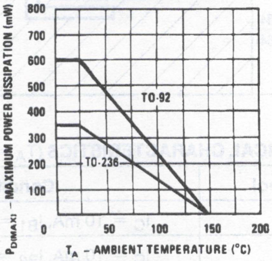
DC Current Gain vs Collector Current



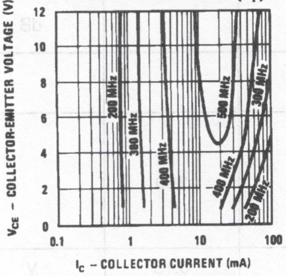
Base-Emitter ON Voltage vs Collector Current



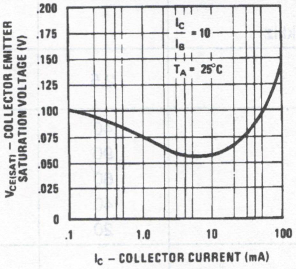
Maximum Power Dissipation vs Ambient Temperature



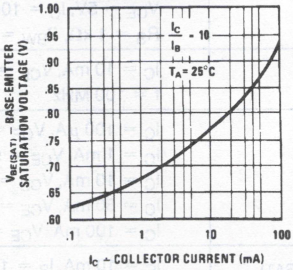
Contours of Constant Gain Bandwidth Product (f_T)



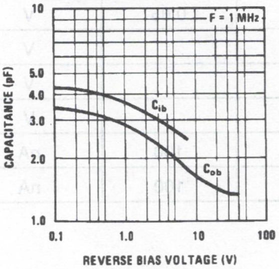
Collector Saturation Voltage vs Collector Current



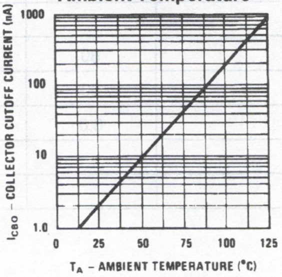
Base Saturation Voltage vs Collector Current



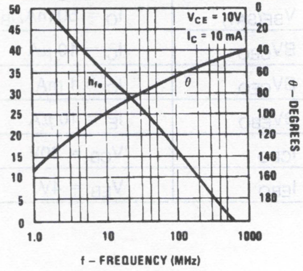
Capacitance vs Reverse Bias Voltage



Collector Cutoff Current vs Ambient Temperature



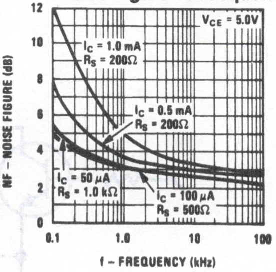
Current Gain and Phase Angle vs Frequency



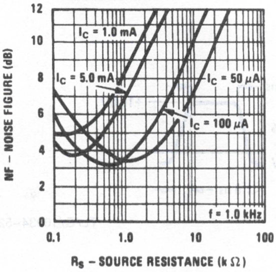
TL/G/10034–48

Process 23

Noise Figure vs Frequency



Noise Figure vs Source Resistance



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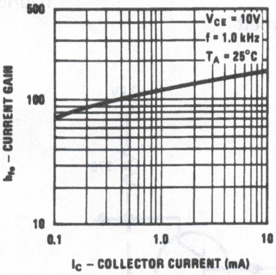
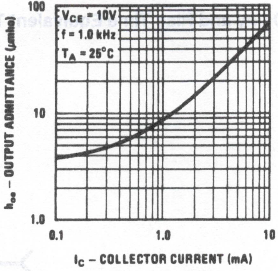
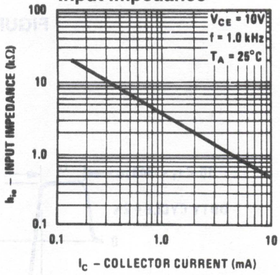
Current Gain



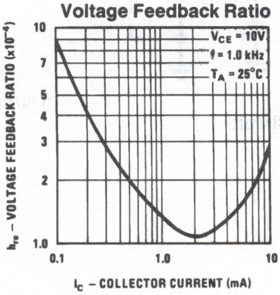
Output Admittance



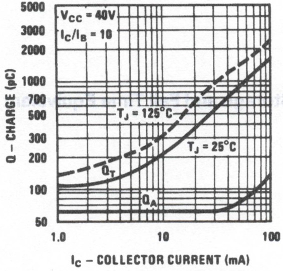
Input Impedance



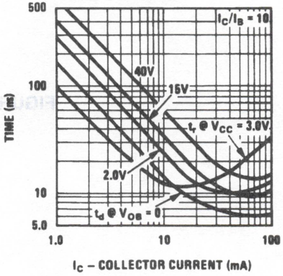
Voltage Feedback Ratio



Charge Data



Turn On Time



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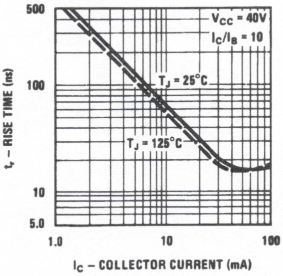
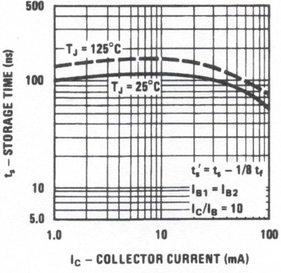
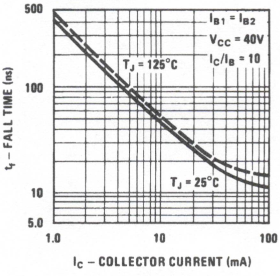
Rise Time



Storage Time



Fall Time



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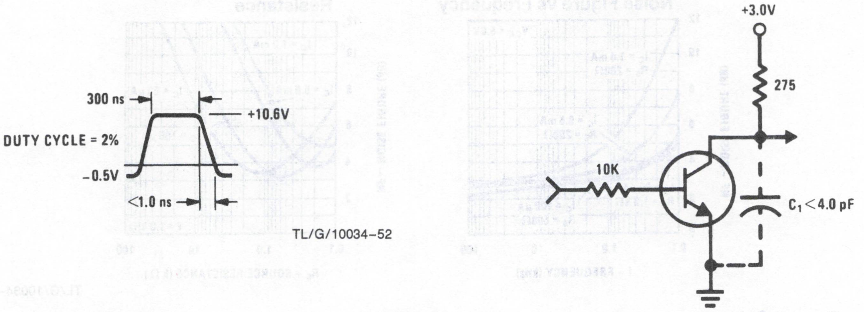
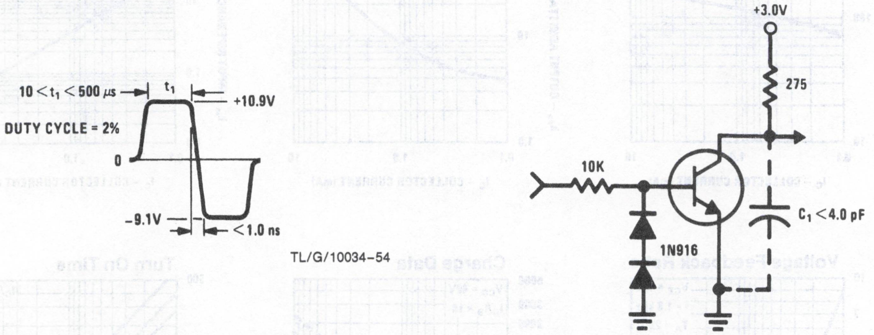
TRANSIENT CHARACTERISTICS


300 ns
+10.6V
DUTY CYCLE = 2%
−0.5V
<1.0 ns
+3.0V
275
10K
$C_1 < 4.0$ pF

TL/G/10034-52

TL/G/10034-53

FIGURE 1. Delay and Rise Time Equivalent Test Circuit


$10 < t_1 < 500$ µs
t_1
+10.9V
DUTY CYCLE = 2%
0
−9.1V
<1.0 ns
+3.0V
275
10K
1N916
$C_1 < 4.0$ pF

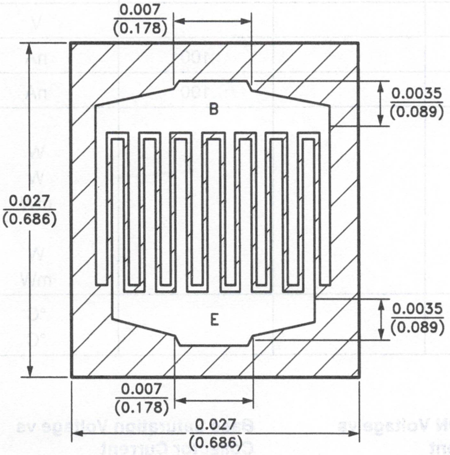
TL/G/10034-54

TL/G/10034-55

FIGURE 2. Storage and Fall Time Equivalent Test Circuit

National Semiconductor

Process 25
NPN Memory Driver



TL/G/10034–56

DESCRIPTION

Process 25 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 70.

APPLICATION

This device was designed for high speed core driver applications up to collector current of 1A.

PRINCIPAL DEVICE TYPES

TO-39 EBC: 2N3725

TO-237 EBC: TN3725

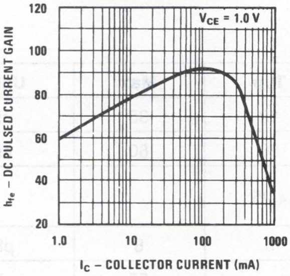
TO-116: MPQ3725

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

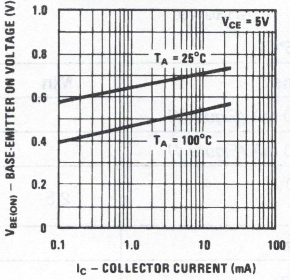
Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	$I_C = 500$ mA, $I_{B1} = 50$ mA *(Figure 1)*		12	35	ns
t_{OFF}	$I_C = 500$ mA, $I_{B2} = 50$ mA *(Figure 1)*		50	60	ns
h_{fe}	$I_C = 50$ mA, $V_{CE} = 10V$, f = 100 MHz	2.5	4.25		
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		6	8	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			55	pF
h_{FE}	$I_C = 10$ mA, $V_{CE} = 1V$	40			
	$I_C = 100$ mA, $V_{CE} = 1V$	45	90	150	
	$I_C = 300$ mA, $V_{CE} = 1V$	35			
	$I_C = 500$ mA, $V_{CE} = 1V$	25			
	$I_C = 800$ mA, $V_{CE} = 1V$	20			
	$I_C = 1A$, $V_{CE} = 1V$	15			
	$I_C = 800$ mA, $V_{CE} = 2V$	25			
	$I_C = 1A$, $V_{CE} = 5V$	25			
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.20	V
	$I_C = 100$ mA, $I_B = 10$ mA			0.20	V
	$I_C = 300$ mA, $I_B = 30$ mA			0.40	V
	$I_C = 500$ mA, $I_B = 50$ mA			0.50	V
	$I_C = 800$ mA, $I_B = 80$ mA			0.80	V
	$I_C = 1A$, $I_B = 100$ mA			1.20	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.70	V
	$I_C = 100$ mA, $I_B = 10$ mA			0.85	V
	$I_C = 300$ mA, $I_B = 30$ mA			1.20	V
	$I_C = 500$ mA, $I_B = 50$ mA			1.20	V
	$I_C = 800$ mA, $I_B = 80$ mA			1.50	V
	$I_C = 1A$, $I_B = 100$ mA			1.70	V

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	40			V
BV_{CBO}	$I_C = 100\ \mu A$	80			V
BV_{EBO}	$I_C = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 40V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
$P_{D(max)}$					
TO-39	$T_C = 25°C$	7			W
	$T_A = 25°C$	1			W
TO-237	$T_A = 25°C$	850			mW
TO-116	$T_A = 25°C$				
	(Total)	1			W
	(Each Transistor)	600			mW
$T_{j(max)}$	All Metal Can Parts	200			°C
	All Plastic Parts	150			°C

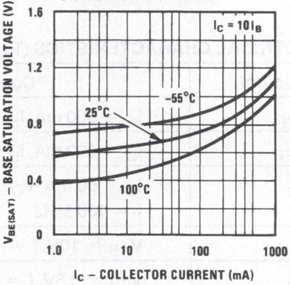
DC Pulsed Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current



Base Saturation Voltage vs Collector Current



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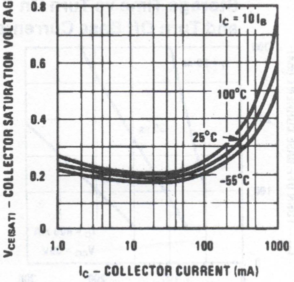
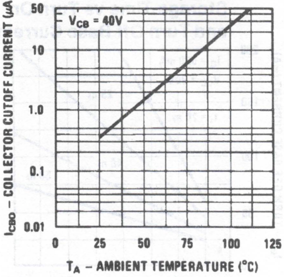
Process 25

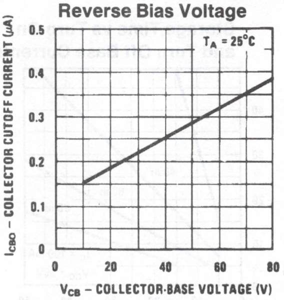
Collector Saturation Voltage vs Collector Current



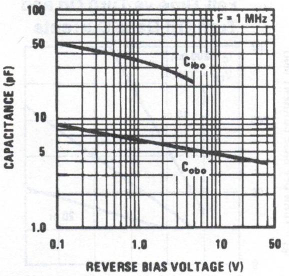
Collector Cutoff Current vs Ambient Temperature



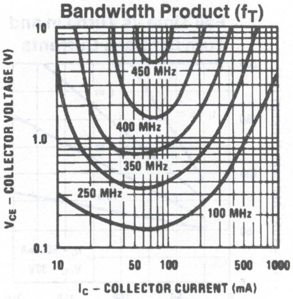
Collector Cutoff Current vs Reverse Bias Voltage



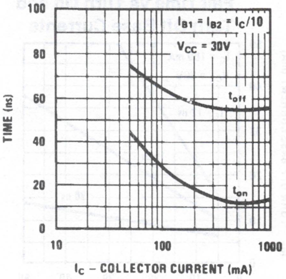
Input and Output Capacitance vs Reverse Bias



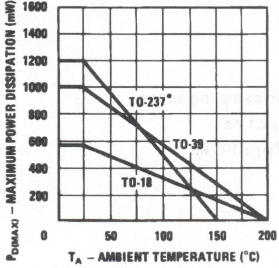
Contours of Constant Bandwidth Product (f_T)



Turn On and Turn Off Times vs Collector Current

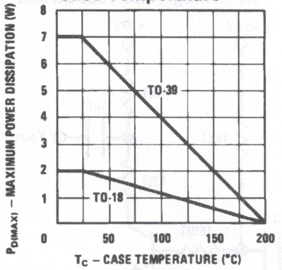


Maximum Power Dissipation vs Ambient Temperature

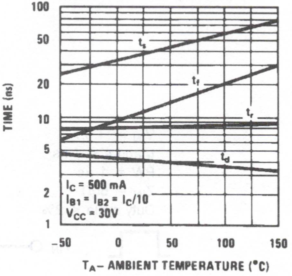


* One square inch of copper run

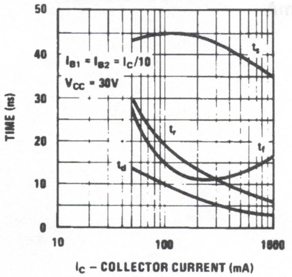
Maximum Power Dissipation vs Case Temperature



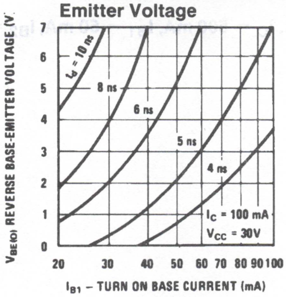
Switching Times vs Ambient Temperature



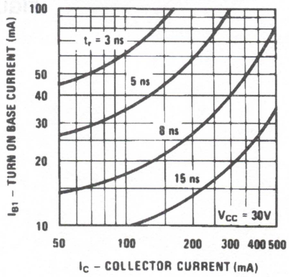
Switching Times vs Collector Current



Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage



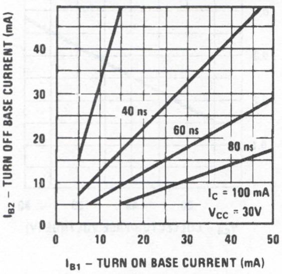
Rise Time vs Collector and Turn On Base Currents



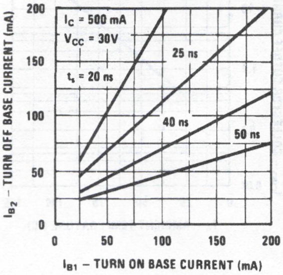
TL/G/10034–58

Process 25

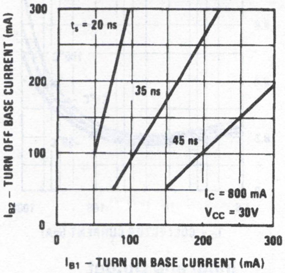
Storage Time vs Turn On and Turn Off Base Currents



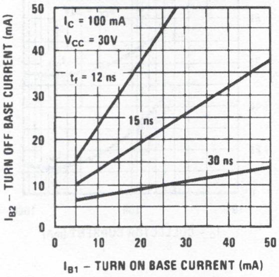
Storage Time vs Turn On and Turn Off Base Currents



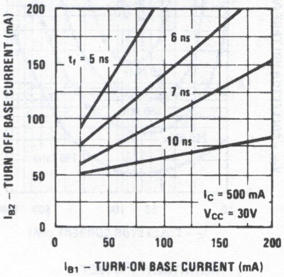
Storage Time vs Turn On and Turn Off Base Currents



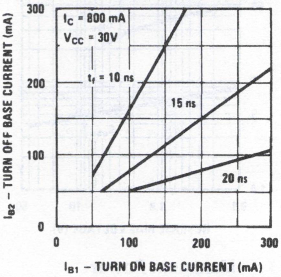
Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents

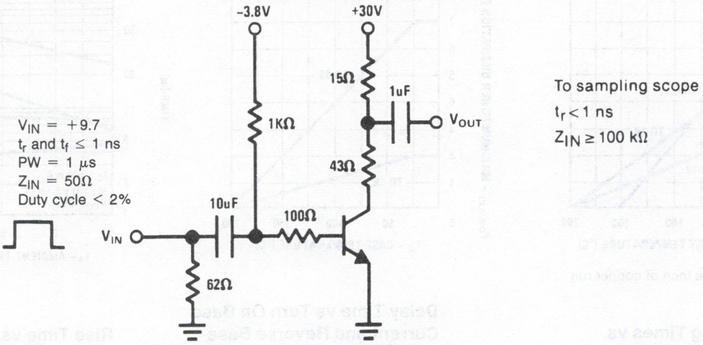


Fall Time vs Turn On and Turn Off Base Currents



TL/G/10034-59

Switching Time Test Circuit


-3.8V
+30V
15Ω
1uF
1KΩ
V_OUT
43Ω
V_IN = +9.7
t_r and t_f ≤ 1 ns
PW = 1 µs
Z_IN = 50Ω
Duty cycle < 2%
10uF
100Ω
V_IN
62Ω
To sampling scope
t_r < 1 ns
Z_IN ≥ 100 kΩ

TL/G/10034-60

FIGURE 1. $I_C = 500\text{ mA}, I_{B1} = 50\text{ mA}, I_{B2} = 50\text{ mA}$

National Semiconductor

Process 34
NPN Planar Power

DESCRIPTION

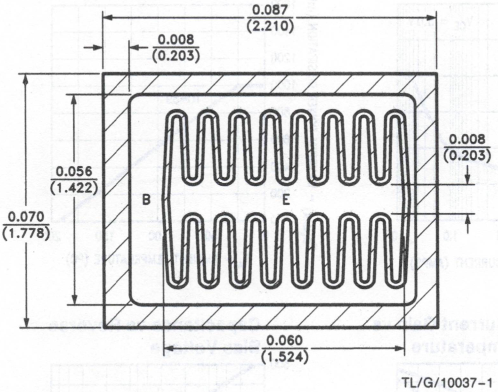
This device is a nonoverlay, double-diffused, silicon epitaxial planar transistor.

APPLICATION

This device was designed for general purpose amplifier applications utilizing collector currents to 5A.

PRINCIPAL DEVICE TYPES

TO-39 EBC: 2N2891



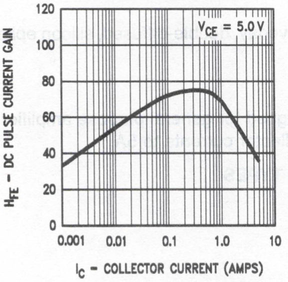
TL/G/10037-1

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

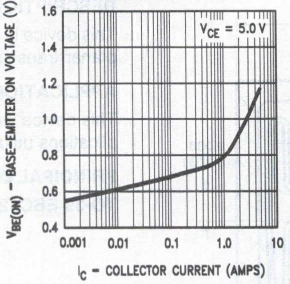
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	80			
BV_{CBO}	$I_C = 100\ \mu A$	100			
BV_{EBO}	$I_E = 10\ \mu A$	8			
I_{CBO}	$V_{CB} = 60V$			100	nA
I_{EBO}	$V_{EB} = 6V$			100	nA
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	40			
	$I_C = 10$ mA, $V_{CE} = 5V$	40			
	$I_C = 100$ mA, $V_{CE} = 5V$	40			
	$I_C = 500$ mA, $V_{CE} = 5V$	40	80	150	
	$I_C = 1A$, $V_{CE} = 5V$	20			
	$I_C = 5A$, $V_{CE} = 5V$	15			
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA		0.05	0.10	V
	$I_C = 1A$, $I_B = 100$ mA		0.20	0.30	
$V_{BE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA		0.70	0.85	V
	$I_C = 1A$, $I_B = 100$ mA		0.90	1.10	
h_{FE}	$I_{CE} = 200$ mA, $V_{CE} = 10V$, f = 20 MHz	4.0	5.0		
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		60	70	pF
C_{ib}	$V_{EB} = 0.5V$, f = 1 MHz			500	pF
t_{ON}	$I_C = 1A$, $I_{B1} = 0.1A$		90	120	ns
t_{OFF}	$I_C = 1A$, $I_{B2} = 0.1A$		200	260	ns
$P_{D(max)}$ TO-39					
	$T_C = 25°C$	7			W
	$T_A = 25°C$	1			W
θ_{JC}	$T_C = 25°C$			25	°C/W
θ_{JA}	$T_A = 25°C$			175	°C/W
$t_{J(max)}$	TO-39		200		°C

Process 34

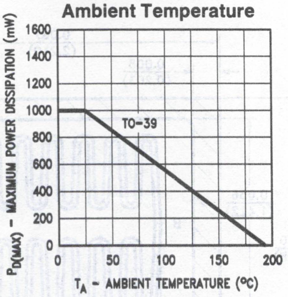
Pulsed DC Current Gain vs Collector Current



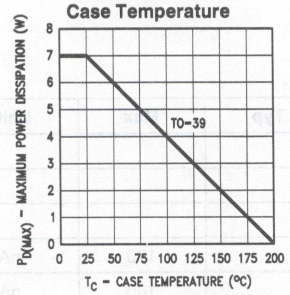
Base-Emitter ON Voltage vs Collector Current



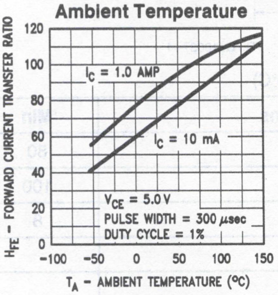
Maximum Power Dissipation vs Ambient Temperature



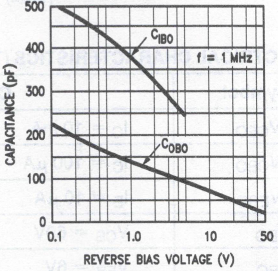
Maximum Power Dissipation vs Case Temperature



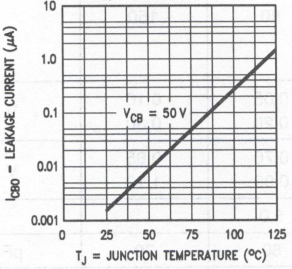
Pulsed DC Current Gain vs Ambient Temperature



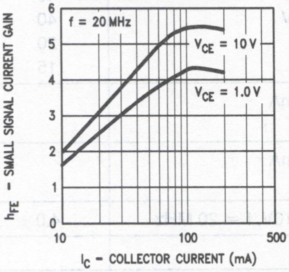
Capacitance vs Reverse Bias Voltage



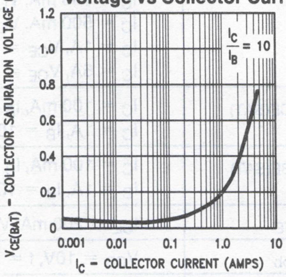
Collector-Base Diode Reverse Current vs Temperature



Small Signal Current Gain vs Collector Current

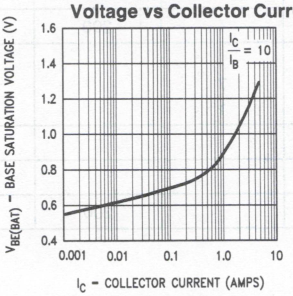


Collector-Emitter Saturation Voltage vs Collector Current

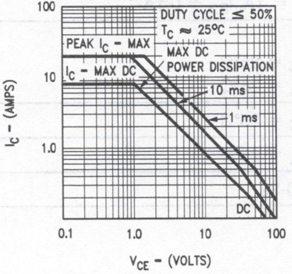


TL/G/10037-2

Base-Emitter Saturation Voltage vs Collector Current



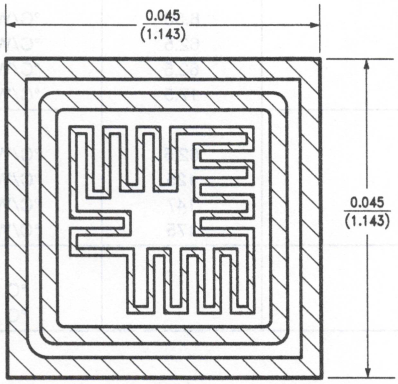
Safe Operating Area



TL/G/10037-3

National Semiconductor

Process 36
NPN High Voltage Power



TL/G/10037-4

DESCRIPTION

Process 36 is a non-overlay, double-diffused, silicon epitaxial planar device with a field plate.

APPLICATION

This device is designed for use in horizontal driver, class A off-line amplifier and off-line switching applications.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D40P1, 3, 5
NSD36-36C

TO-237 EBC: 2N6720-23, TN3440

TO-39: 2N3440

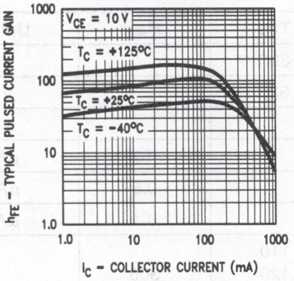
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_{CE} = 1$ mA (Note 1)	200	300		V
BV_{CBO}	$I_{CB} = 100\ \mu A$	225	325		V
BV_{EBO}	$I_{EB} = 10\ \mu A$	6			V
I_{CEO}	$V_{CE} = 200V$			10	μA
I_{CBO}	$V_{CB} = 225V$			0.5	μA
I_{EBO}	$V_{EB} = 5V$			0.1	μA
h_{FE}	$I_C = 50$ mA, $V_{CE} = 10V$ (Note 1)		110		
	$I_C = 100$ mA, $V_{CE} = 10V$ (Note 1)	30	120	300	
	$I_C = 250$ mA, $V_{CE} = 10V$ (Note 1)		60		
	$I_C = 500$ mA, $V_{CE} = 10V$ (Note 1)		25		
$V_{CE(SAT)}$	$I_C = 100$ mA, $I_B = 10$ mA (Note 1)		0.2	0.5	V
	$I_C = 500$ mA, $I_B = 100$ mA (Note 1)		0.3	0.7	
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 100$ mA (Note 1)		0.9	1.2	V
$V_{BE(ON)}$	$I_C = 100$ mA, $V_{CE} = 10V$ (Note 1)		0.7	1.0	V
f_t	$I_C = 50$ mA, $V_{CE} = 10V$	20	60		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz			15	pF
C_{ib}	$V_{BE} = 0.5V$, f = 1 MHz			125	pF
$P_{D(max)}$					
TO-202	$T_C = 25°C$	15			W
	$T_A = 25°C$	2			
TO-226	$T_C = 25°C$	2			W
	$T_A = 25°C$	1			
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-39	$T_C = 25°C$	10			W
	$T_A = 25°C$	1			

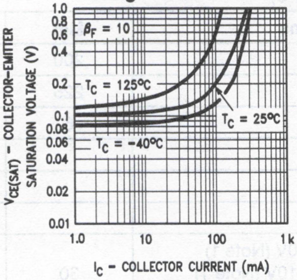
Process 36

Symbol	Conditions	Min	Typ	Max	Units
θ_{JC}					
TO-202	$T_C = 25°C$			8.33	°C/W
TO-226	$T_C = 25°C$			62.5	°C/W
TO-237	$T_C = 25°C$			62.5	°C/W
TO-39	$T_C = 25°C$			17.5	°C/W
θ_{JA}					
TO-202	$T_A = 25°C$			62.5	°C/W
TO-226	$T_A = 25°C$			125	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-39	$T_A = 25°C$			175	°C/W
$T_{J(max)}$					
	All Plastic Parts	150			°C
	TO-39	200			°C

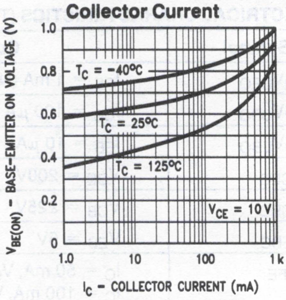
Typical Current Gain vs Collector Current



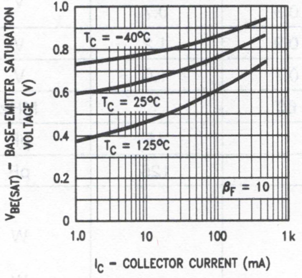
Collector-Emitter Saturation Voltage vs Collector Current



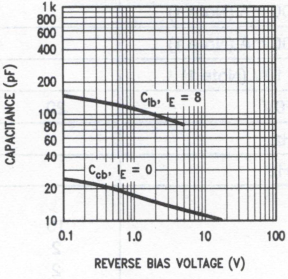
Base-Emitter ON Voltage vs Collector Current



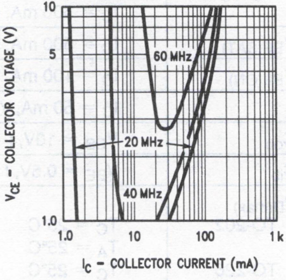
Base-Emitter Saturation Voltage vs Collector Current



Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage



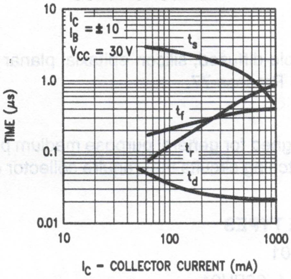
Contours of Constant Gain Bandwidth Product (f_t)



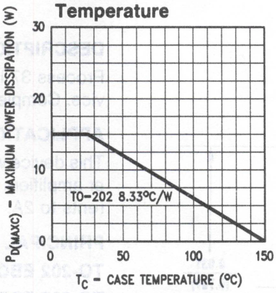
TL/G/10037-5

Process 36

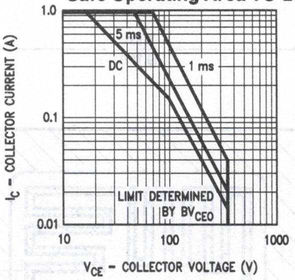
Typical Switching Time vs Collector Current



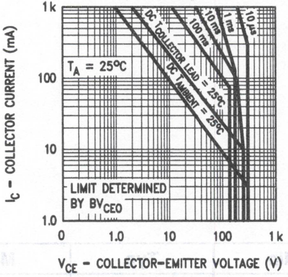
Maximumn Power Dissipation vs Case Temperature



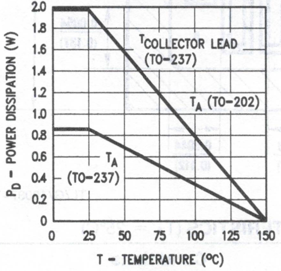
Safe Operating Area TO-202



Safe Operating Area TO-237



Thermal Derating Curve



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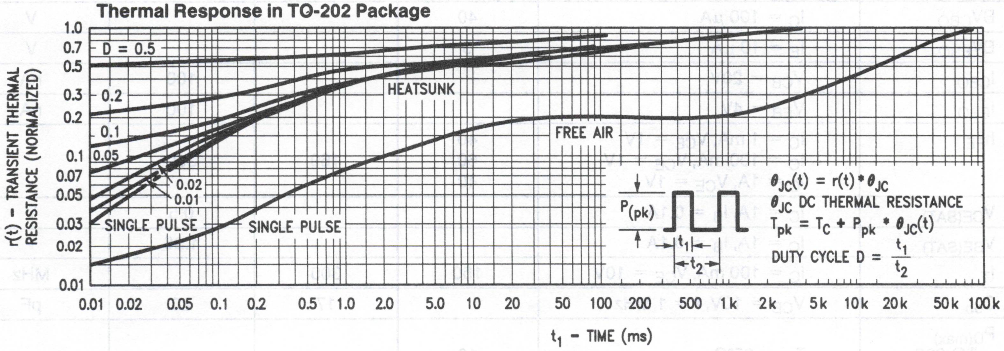
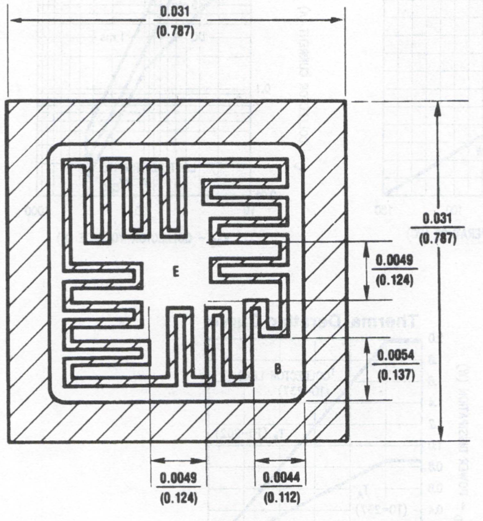
Thermal Response in TO-202 Package



TL/G/10037-6

National Semiconductor

Process 37
NPN Medium Power



TL/G/10037-7

DESCRIPTION

Process 37 is a double-diffused, silicon epitaxial planar device. Complement to Process 77.

APPLICATION

This device was designed for general purpose medium power amplifiers and switching circuits that require collector currents to 2A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: NSDU01

TO-237 EBC: 2N6714, 92PU01

TO-226 EBC: MPS6714

TO-92 EBC: PN6714

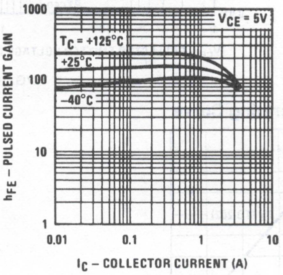
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	25			V
BV_{CBO}	$I_C = 100\ \mu A$	40			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 20V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$ $I_C = 100$ mA, $V_{CE} = 1V$ $I_C = 1A$, $V_{CE} = 1V$	40 60 40	160	360	
$V_{CE(SAT)}$	$I_C = 1A$, $I_B = 0.1A$			0.5	V
$V_{BE(SAT)}$	$I_C = 1A$, $I_B = 0.1A$			1.25	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	150	300		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		17	20	pF
$P_{D(max)}$					
TO-202	$T_C = 25°C$ $T_A = 25°C$	10 2			W
TO-226	$T_C = 25°C$ $T_A = 25°C$	2 1			W
TO-237	$T_C = 25°C$ $T_A = 25°C$	2 850			W mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-202	$T_C = 25°C$			12.5	°C/W
TO-226	$T_C = 25°C$			62.5	°C/W
TO-237	$T_C = 25°C$			62.5	°C/W
TO-92	$T_C = 25°C$			125	°C/W

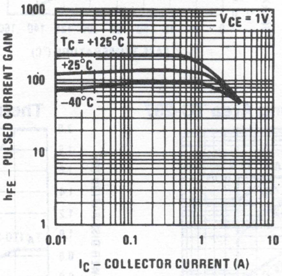
Process 37

Symbol	Conditions	Min	Typ	Max	Units
θ_{JA}					
TO-202	$T_A = 25°C$			62.5	°C/W
TO-226	$T_A = 25°C$			125	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

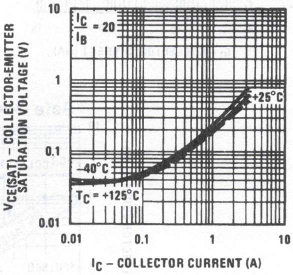
Typical Pulsed Current Gain vs Collector Current



Typical Pulsed Current Gain vs Collector Current

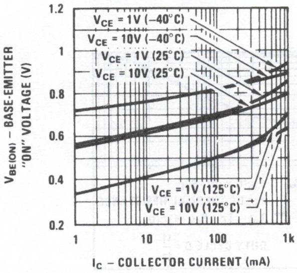


Collector-Emitter Saturation Voltage vs Collector Current

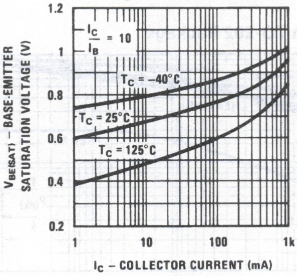


TL/G/10037-8

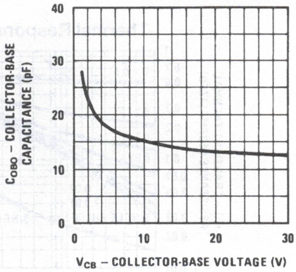
Base-Emitter ON Voltage vs Collector Current



Base-Emitter Saturation Voltage vs Collector Current

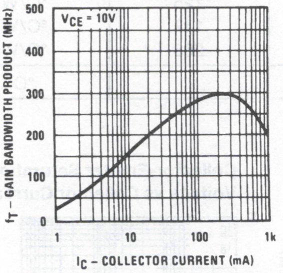


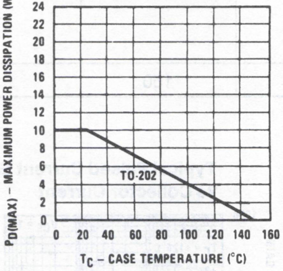
Collector-Base Capacitance vs Collector-Base Voltage

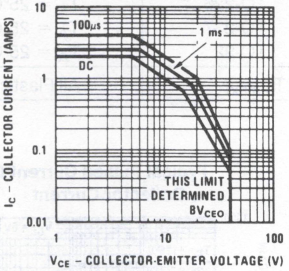


TL/G/10037-9

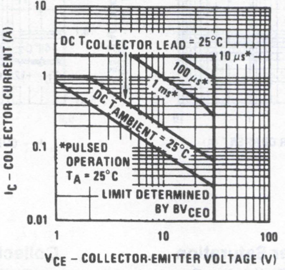
Process 37

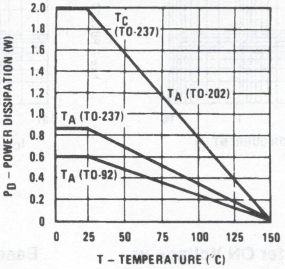

Gain Bandwidth Product vs Collector Current


Maximum Power Dissipation vs Case Temperature

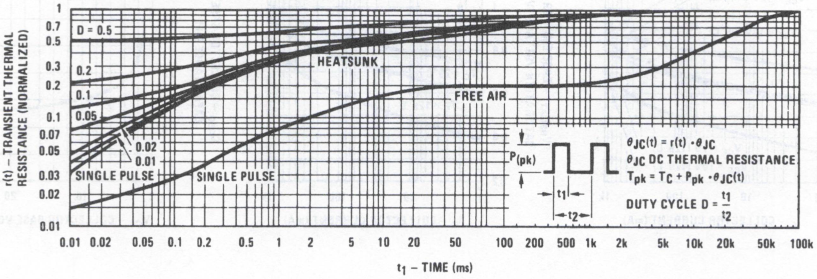

Safe Operating Area TO-202

TL/G/10037-10


Safe Operating Area TO-237


Thermal Derating Curve

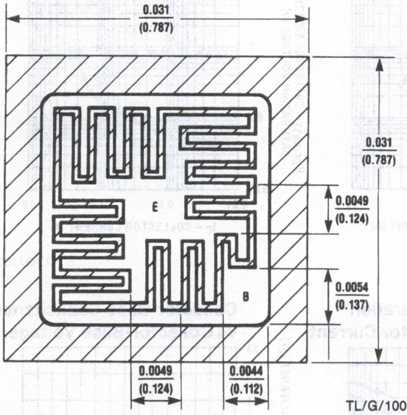
TL/G/10037-11


Thermal Response in TO-202 Package

TL/G/10037-13

National Semiconductor

Process 38
NPN Medium Power



TL/G/10037-14

DESCRIPTION

Process 38 is a double-diffused, silicon epitaxial planar device. Complement to Process 78.

APPLICATION

This device was designed for general purpose medium power amplifiers and switching circuits that require collector currents to 1.5A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D40D1-6, NSDU05

TO-237 EBC: 2N6715, 92PU05

TO-92 EBC: PN6715

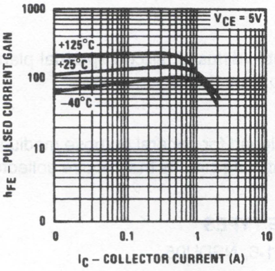
TO-226 EBC: MPS6715

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

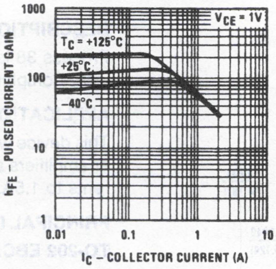
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	I_C = 10 mA	40			V
BV_{CBO}	I_C = 100 μA	65			V
BV_{EBO}	I_E = 10 μA	5			V
I_{CBO}	V_{CB} = 40V			100	nA
I_{EBO}	V_{EB} = 4V			100	nA
h_{FE}	I_C = 1 mA, V_{CE} = 1V I_C = 100 mA, V_{CE} = 1V I_C = 1A, V_{CE} = 1V	40 60 20	 160 	 360 	
$V_{CE(SAT)}$	I_C = 500 mA, I_B = 50 mA			0.5	V
$V_{BE(SAT)}$	I_C = 500 mA, I_B = 50 mA			1.25	V
f_T	I_C = 100 mA, V_{CE} = 10V	125	250		MHz
C_{ob}	V_{CB} = 10V, f = 1 MHz		14	18	pF
$P_{D(max)}$ TO-202 TO-226 TO-237 TO-92	 T_C = 25°C T_A = 25°C T_C = 25°C T_A = 25°C T_C = 25°C T_A = 25°C T_A = 25°C	 10 2 2 1 2 850 600			 W W W W mW mW
θ_{JC} TO-202 TO-237	 T_C = 25°C T_C = 25°C			 12.5 62.5	 °C/W °C/W
θ_{JA} TO-202 TO-226 TO-237 TO-92	 T_A = 25°C T_A = 25°C T_A = 25°C T_A = 25°C			 62.5 125 147 208	 °C/W °C/W °C/W °C/W
$T_{J(max)}$	All Plastic Parts	150			°C

Process 38

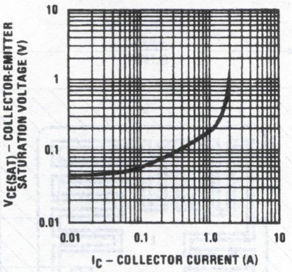
Typical Pulsed Current Gain vs Collector Current



Typical Pulsed Current Gain vs Collector Current

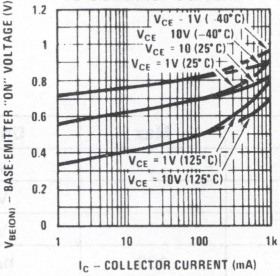


Collector-Emitter Saturation Voltage vs Collector Current

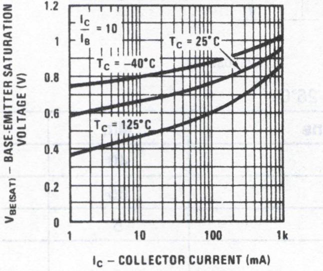


TL/G/10037-15

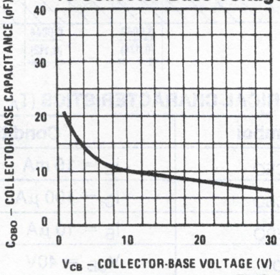
Base-Emitter ON Voltage vs Collector Current



Base-Emitter Saturation Voltage vs Collector Current

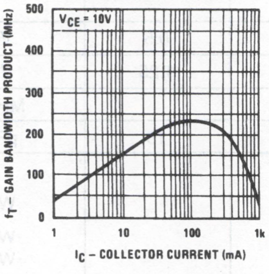


Collector-Base Capacitance vs Collector-Base Voltage

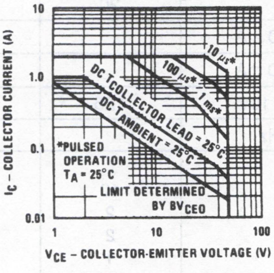


TL/G/10037-16

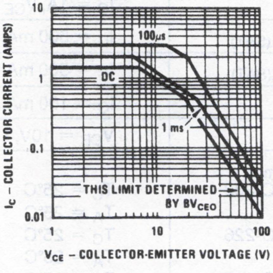
Gain Bandwidth Product vs Collector Current



Safe Operating Area TO-237

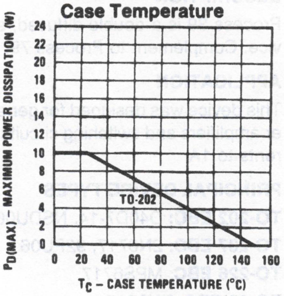


Safe Operating Area TO-202

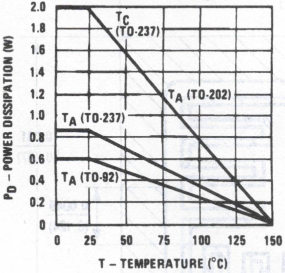


TL/G/10037-17

Process 38

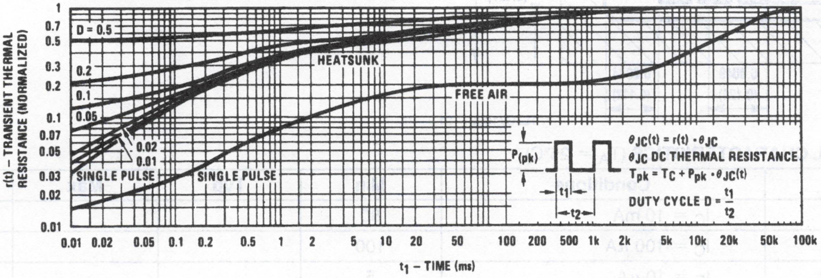


Maximum Power Dissipation vs Case Temperature



Thermal Derating Curve

TL/G/10037-18

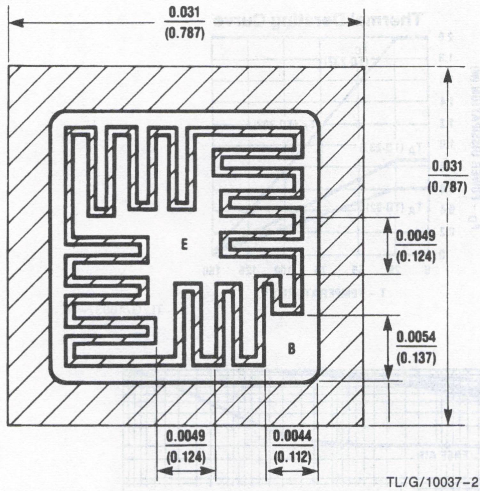


Thermal Response in TO-202 Package

TL/G/10037-20

National Semiconductor

Process 39
NPN Medium Power



TL/G/10037-21

DESCRIPTION

Process 39 is a double-diffused, silicon epitaxial planar device. Complement to Process 79.

APPLICATION

This device was designed for general purpose medium power amplifiers and switching circuits that require collector currents to 1A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D40D7-14, NSDU06

TO-237 EBC: 2N6717, 92PU06

TO-226 EBC: MPS6717

TO-92 EBC: PN6717

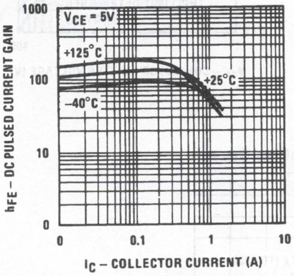
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	I_C = 10 mA	80			V
BV_{CBO}	I_C = 100 μA	100			V
BV_{EBO}	I_E = 10 μA	5			V
I_{CBO}	V_{CB} = 80V			100	nA
I_{EBO}	V_{EB} = 4V			100	nA
h_{FE}	I_C = 100 mA, V_{CE} = 1V	50		300	
	I_C = 500 mA, V_{CE} = 1V	20			
$V_{CE(SAT)}$	I_C = 500 mA, I_B = 50 mA			0.8	V
$V_{BE(SAT)}$	I_C = 500 mA, I_B = 50 mA			1.3	V
f_T	I_C = 100 mA, V_{CE} = 10V	80	150		MHz
C_{ob}	V_{CB} = 10V, f = 1 MHz		10	15	pF
$P_{D(max)}$					
TO-202	T_C = 25°C	10			W
	T_A = 25°C	2			
TO-226	T_C = 25°C	2			W
	T_A = 25°C	1			W
TO-237	T_C = 25°C	2			W
	T_A = 25°C	850			mW
TO-92	T_A = 25°C	600			mW
θ_{JC}					
TO-202	T_C = 25°C			12.5	°C/W
TO-237	T_C = 25°C			62.5	°C/W

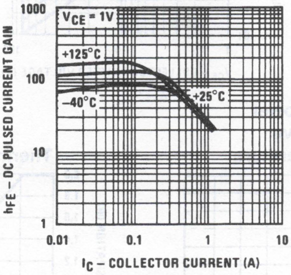
Process 39

Symbol	Conditions	Min	Typ	Max	Units
θ_{JA}					
TO-202	$T_A = 25°C$			62.5	°C/W
TO-226	$T_A = 25°C$			125	°C/W
TO-237	$T_A = 25°C$			147	°C/W
TO-92	$T_A = 25°C$			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

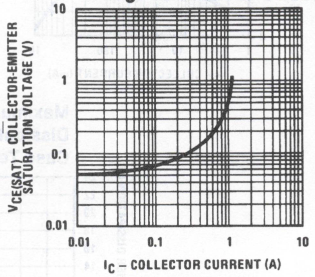
Typical Pulsed Current Gain vs Collector Current



Typical Pulsed Current Gain vs Collector Current

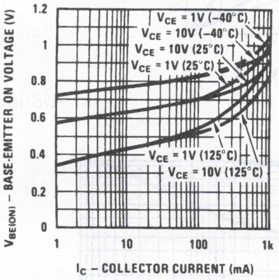


Collector-Emitter Saturation Voltage vs Collector Current

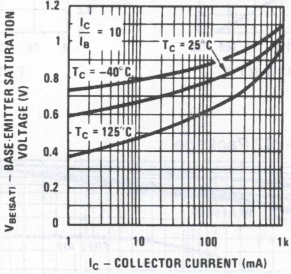


TL/G/10037–22

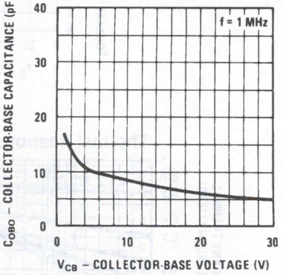
Base-Emitter ON Voltage vs Collector Current



Base-Emitter Saturation Voltage vs Collector Current



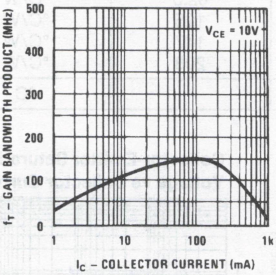
Collector-Base Capacitance vs Collector-Base Voltage



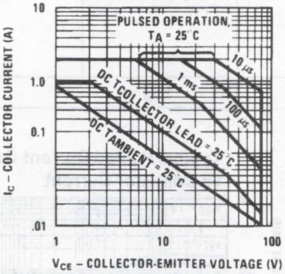
TL/G/10037–23

Process 39

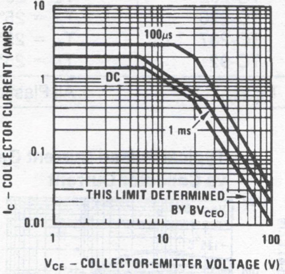
Gain Bandwidth Product vs Collector Current



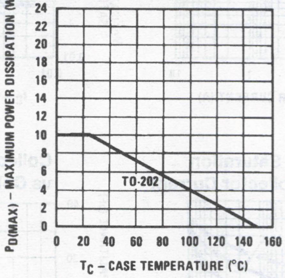
Safe Operating Area TO-237



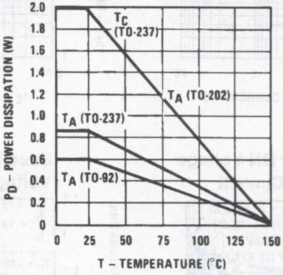
Safe Operating Area TO-202



Maximum Power Dissipation vs Case Temperature

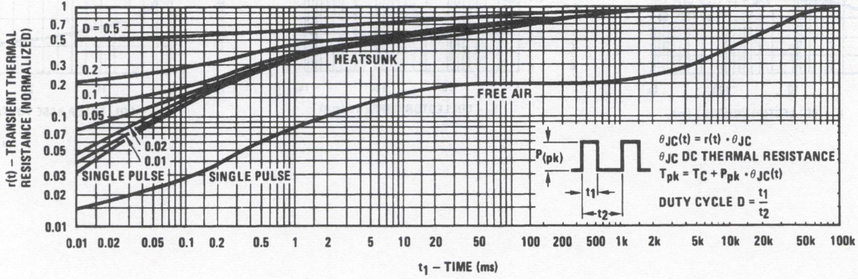


Thermal Derating Curve



TL/G/10037-76

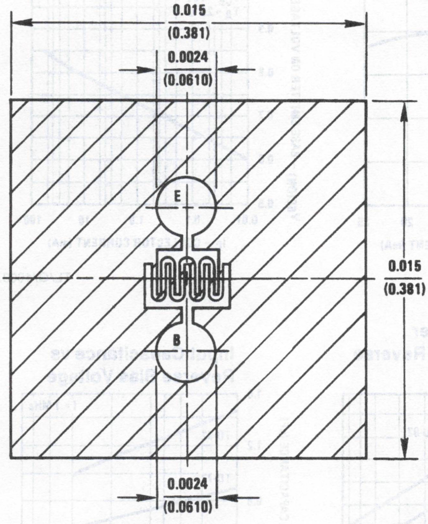
Thermal Response in TO-202 Package



TL/G/10037-25

National Semiconductor

Process 40
NPN RF Amplifier



TL/G/10037-26

DESCRIPTION

Process 40 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device was designed for use in low noise UHF/VHF amplifiers with collector current in the 100 μA to 20 mA range in common emitter or common base mode of operation, and in low frequency drift, high output UHF oscillators.

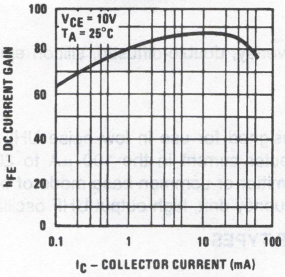
PRINCIPAL DEVICE TYPES

TO-72: 2N5179
TO-92: MPS5179
TO-236: MMBT5719

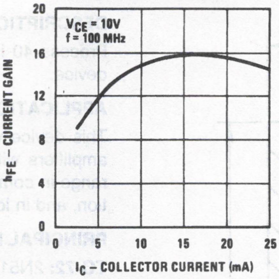
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
P_G	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA *(Figure 1)*	12	16		dB
NF	f = 450 MHz, V_{CE} = 10V, I_C = 2 mA, R_G = 50Ω *(Figure 1)*		3.0	5.0	dB
P_{OUT}	f = 500 MHz, V_{CB} = 15V, I_E = 10 mA (TO-92) *(Figure 2)*	40	65		mW
h_{fe}	f = 100 MHz, V_{CE} = 10V, I_C = 10 mA	10	15		
rb′Cc	f = 79.8 MHz, V_{CE} = 10V, I_C = 5 mA			10	ps
C_{CB}	f = 1.0 MHz, V_{CB} = 10V, I_E = 0 (TO-72)		0.5	0.6	pF
C_{CE}	f = 1.0 MHz, V_{CE} = 10V, I_B = 0 (TO-72)		0.2	0.3	pF
C_{EB}	f = 1.0 MHz, V_{EB} = 0.5V, I_C = 0 (TO-72)		0.8	1.5	pF
h_{FE}	V_{CE} = 10V, I_C = 5 mA V_{CE} = 6V, I_C = 1 mA	40 30	90	200	
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 5 mA			0.2	V
BV_{CEO}	I_C = 1 mA	20			V
BV_{CBO}	I_C = 10 μA	30			V
BV_{EBO}	I_E = 10 μA	4.0			V
I_{CBO}	V_{CB} = 20V			100	nA
I_{EBO}	V_{EB} = 3V			100	nA

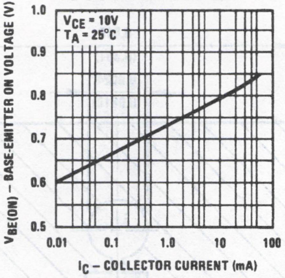
Process 40



DC Current Gain vs Collector Current

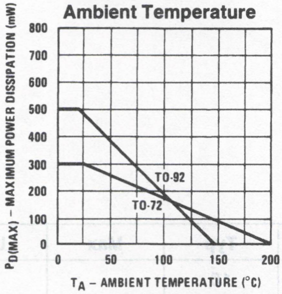


Current Gain at 100 MHz vs Collector Current

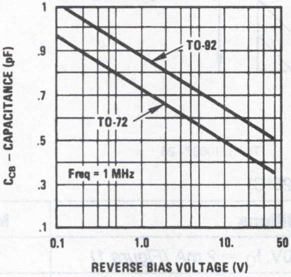


Base-Emitter ON Voltage vs Collector Current

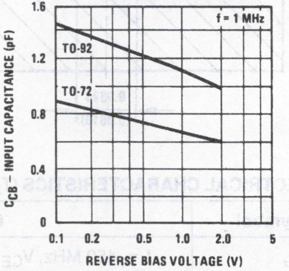
TL/G/10037–27



Maximum Power Dissipation vs Ambient Temperature

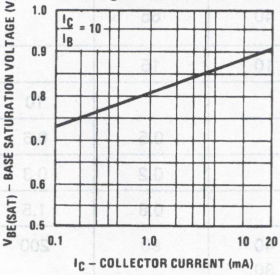


Reverse Transfer Capacitance vs Reverse Bias Voltage

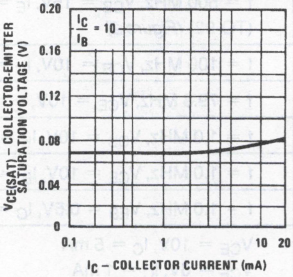


Input Capacitance vs Reverse Bias Voltage

TL/G/10037–28

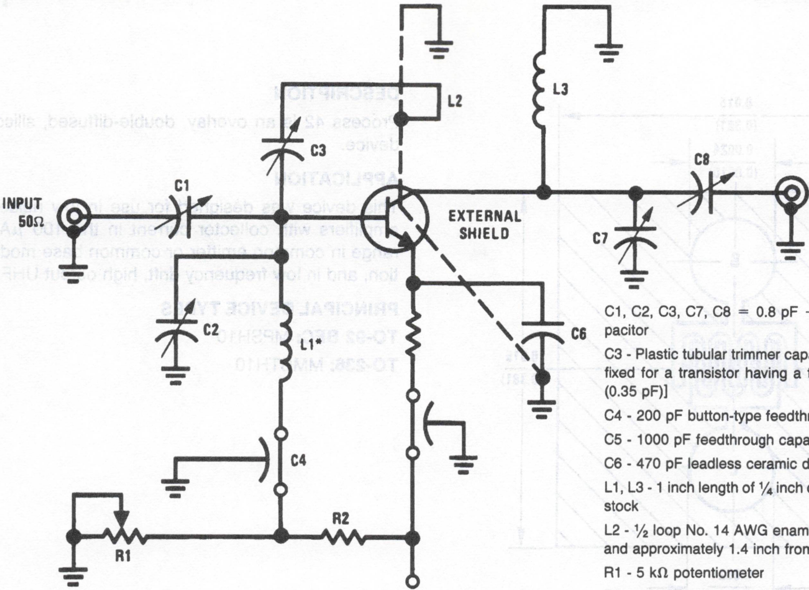


Base-Emitter Saturation Voltage vs Collector Current



Collector-Emitter Saturation Voltage vs Collector Current

TL/G/10037–29


L2
L3
C3
C1
C8
INPUT
50Ω
OUTPUT
50Ω
EXTERNAL
SHIELD
C7
C2
L1*
C6
C4
R2
R1

C1, C2, C3, C7, C8 = 0.8 pF −10 pF variable capacitor

C3 - Plastic tubular trimmer capacitor [adjusted and fixed for a transistor having a typical value of C_{cb} (0.35 pF)]

C4 - 200 pF button-type feedthrough capacitor

C5 - 1000 pF feedthrough capacitor

C6 - 470 pF leadless ceramic disc capacitor

L1, L3 - 1 inch length of ¼ inch diameter copper bar stock

L2 - ½ loop No. 14 AWG enameled wire parallel to and approximately 1.4 inch from L3

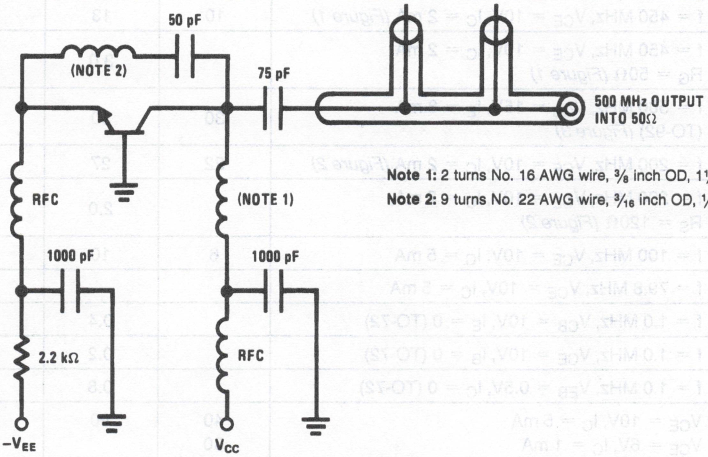
R1 - 5 kΩ potentiometer

R2 - 1.2 kΩ

R3 - 2 kΩ

TL/G/10037-30

FIGURE 1. Neutralized 450 MHz Gain and Noise Figure Circuit


50 pF
(NOTE 2)
75 pF
500 MHz OUTPUT
INTO 50Ω
RFC
(NOTE 1)
1000 pF
1000 pF
2.2 kΩ
RFC
$-V_{EE}$
V_{CC}

Note 1: 2 turns No. 16 AWG wire, ⅜ inch OD, 1¼ inch long.

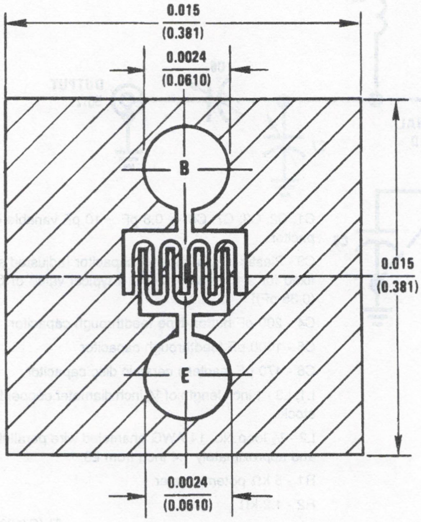
Note 2: 9 turns No. 22 AWG wire, $^{3}/_{16}$ inch OD, ½ inch long.

TL/G/10037-31

FIGURE 2. 500 MHz Oscillator Circuit

National Semiconductor

Process 42
NPN RF Amplifier



TL/G/10037-32

DESCRIPTION

Process 42 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device was designed for use in low noise UHF/VHF amplifiers with collector current in the 100 μA to 10 mA range in common emitter or common base mode of operation, and in low frequency drift, high output UHF oscillators.

PRINCIPAL DEVICE TYPES

TO-92 BEC: MPSH10

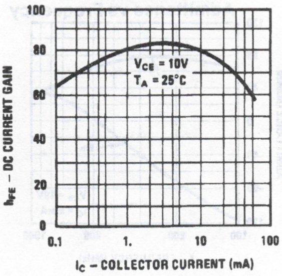
TO-236: MMBTH10

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

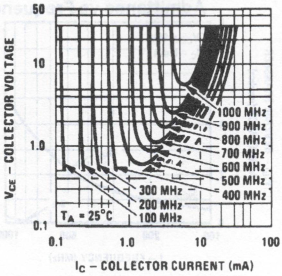
Symbol	Conditions	Min	Typ	Max	Units
P_G	f = 450 MHz, $V_{CE} = 10V$, $I_C = 2$ mA *(Figure 1)*	10	13		dB
NF	f = 450 MHz, $V_{CE} = 10V$, $I_C = 2$ mA, $R_G = 50\Omega$ *(Figure 1)*		3.0	5.0	dB
P_{OUT}	f = 500 MHz, $V_{CB} = 15V$, $I_E = 8$ mA (TO-92) *(Figure 3)*	30	50		mW
P_G	f = 200 MHz, $V_{CE} = 10V$, $I_C = 2$ mA *(Figure 2)*	22	27		dB
NF	f = 200 MHz, $V_{CE} = 10V$, $I_C = 2$ mA, $R_S = 120\Omega$ *(Figure 2)*		2.0	3.5	dB
h_{fe}	f = 100 MHz, $V_{CE} = 10V$, $I_C = 5$ mA	6	10		
rb′Cc	f = 79.8 MHz, $V_{CE} = 10V$, $I_C = 5$ mA			10	ps
C_{CB}	f = 1.0 MHz, $V_{CB} = 10V$, $I_E = 0$ (TO-72)		0.4	0.5	pF
C_{CE}	f = 1.0 MHz, $V_{CE} = 10V$, $I_B = 0$ (TO-72)		0.2	0.3	pF
C_{EB}	f = 1.0 MHz, $V_{EB} = 0.5V$, $I_C = 0$ (TO-72)		0.8	1.5	pF
h_{FE}	$V_{CE} = 10V$, $I_C = 5$ mA $V_{CE} = 6V$, $I_C = 1$ mA	40 30	90	200	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 5$ mA			0.2	V
BV_{CEO}	$I_C = 1$ mA	30			V
BV_{CBO}	$I_C = 10\ \mu$A	35			V
BV_{EBO}	$I_E = 10\ \mu$A	4			V
I_{CBO}	$V_{CB} = 30V$			100	nA
I_{EBO}	$V_{EB} = 3V$			100	nA

Process 42

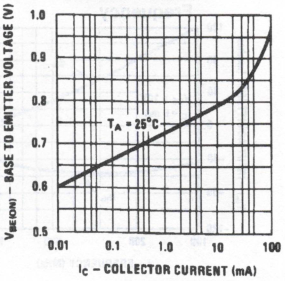
DC Current Gain vs Collector Current



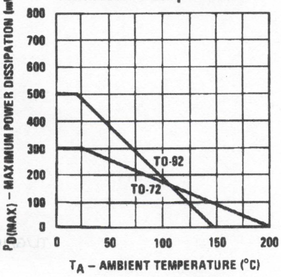
Contours of Constant Gain Bandwidth Product (f_T)



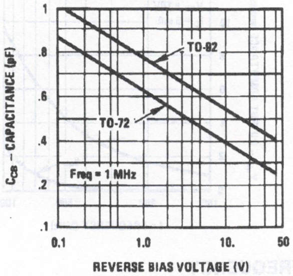
Base-Emitter ON Voltage vs Collector Current



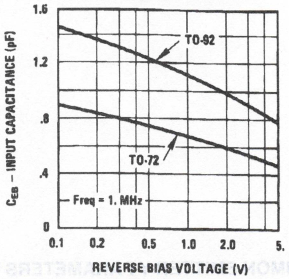
Maximum Power Dissipation vs Ambient Temperature



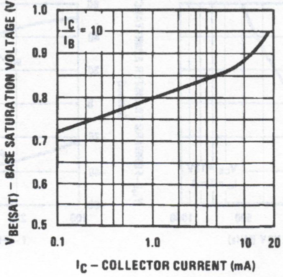
Reverse Transfer Capacitance vs Reverse Bias Voltage



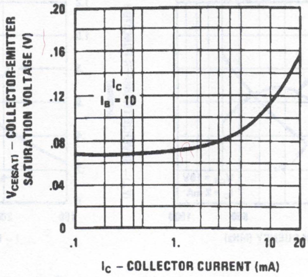
Input Capacitance vs Reverse Bias Voltage



Base-Emitter Saturation Voltage vs Collector Current



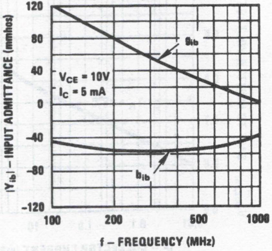
Collector-Emitter Saturation Voltage vs Collector Current

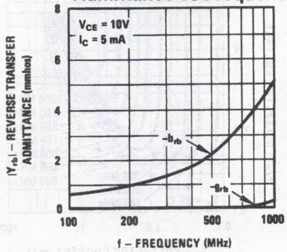


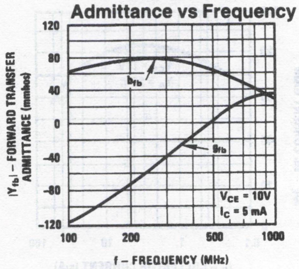
TL/G/10037-33

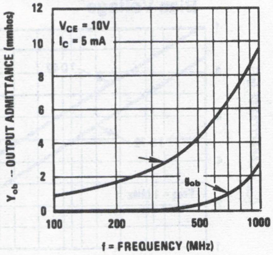
Process 42

COMMON BASE Y PARAMETERS VS FREQUENCY


Input Admittance vs Frequency

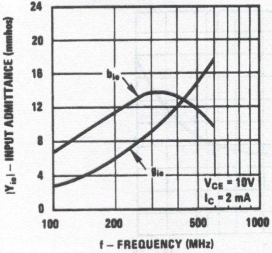

Reverse Transfer Admittance vs Frequency

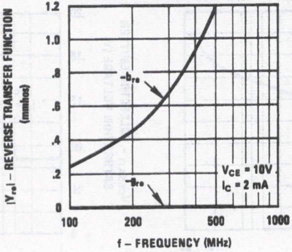

Forward Transfer Admittance vs Frequency

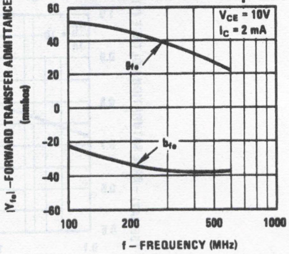

Output Admittance vs Frequency

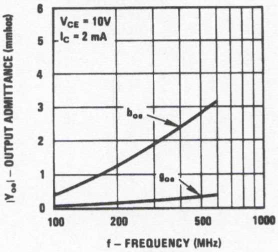
TL/G/10037-34

COMMON EMITTER Y PARAMETERS VS FREQUENCY


Input Admittance vs Frequency

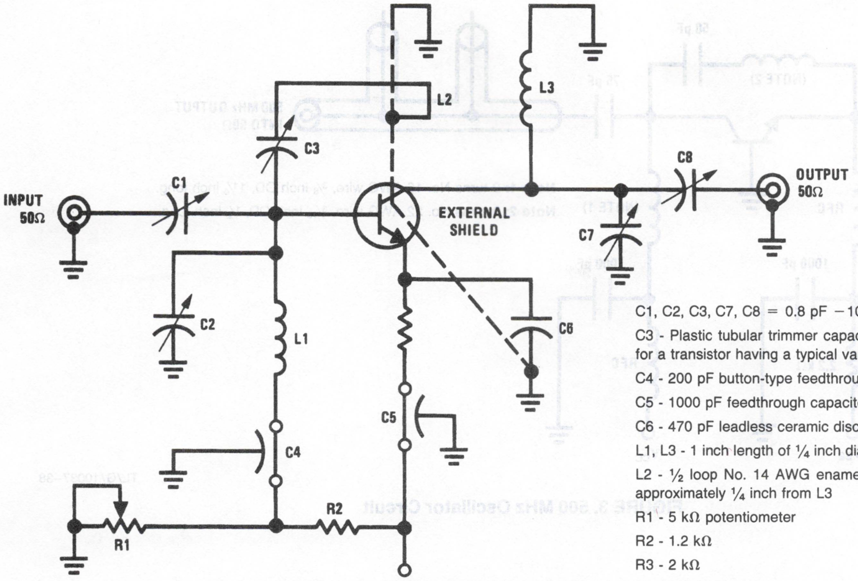

Reverse Transfer Admittance vs Frequency


Forward Transfer Admittance vs Frequency


Output Admittance vs Frequency

TL/G/10037-35

Process 42


INPUT 50Ω
C1
C2
C3
L1
L2
L3
EXTERNAL SHIELD
C4
C5
C6
C7
C8
OUTPUT 50Ω
R1
R2

C1, C2, C3, C7, C8 = 0.8 pF − 10 pF variable capacitor

C3 - Plastic tubular trimmer capacitor [adjusted and fixed for a transistor having a typical value of C_{cb} (0.35 pF)]

C4 - 200 pF button-type feedthrough capacitor

C5 - 1000 pF feedthrough capacitor

C6 - 470 pF leadless ceramic disc capacitor

L1, L3 - 1 inch length of ¼ inch diameter copper bar stock

L2 - ½ loop No. 14 AWG enameled wire parallel to and approximately ¼ inch from L3

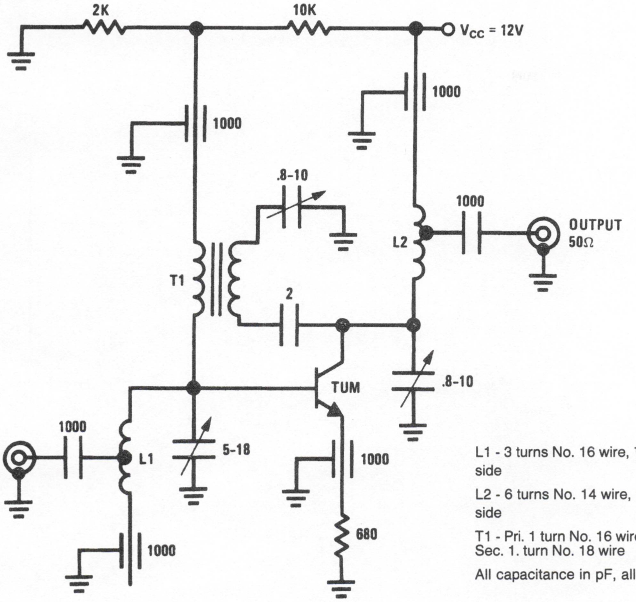
R1 - 5 kΩ potentiometer

R2 - 1.2 kΩ

R3 - 2 kΩ

FIGURE 1. Neutralized 450 MHz Gain and Noise Figure Circuit

TL/G/10037–36


2K
10K
V_{CC} = 12V
1000
1000
.8-10
T1
1000
L2
OUTPUT 50Ω
2
TUM
.8-10
INPUT 50Ω
1000
L1
5-18
1000
680
1000

L1 - 3 turns No. 16 wire, ½ inch L x ¼ inch ID tapped 1½ turns from cold side

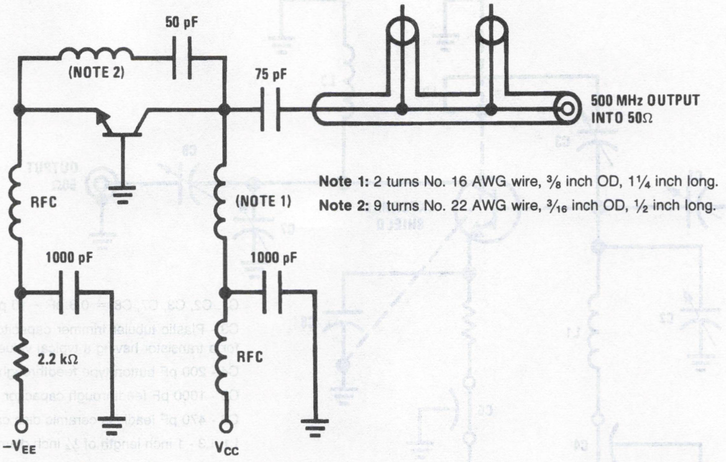
L2 - 6 turns No. 14 wire, 1 inch L x ¼ inch ID tapped 1½ turns from cold side

T1 - Pri. 1 turn No. 16 wire
Sec. 1. turn No. 18 wire } Core is Indiana General P/N F-684-Q3

All capacitance in pF, all resistance in Ω.

TL/G/10037–37

FIGURE 2. Neutralized 200 MHz PF and NF Circuit


50 pF
(NOTE 2)
75 pF
500 MHz OUTPUT INTO 50Ω
RFC
(NOTE 1)
1000 pF
1000 pF
2.2 kΩ
RFC
$-V_{EE}$
V_{CC}

Note 1: 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.

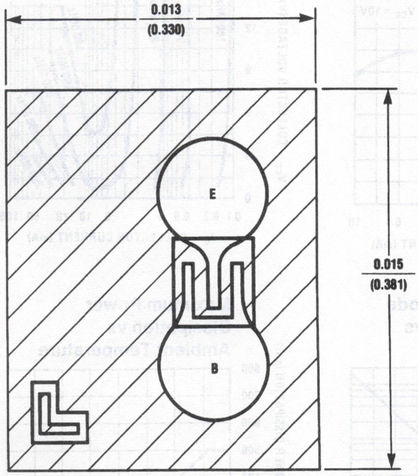
Note 2: 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

TL/G/10037–38

FIGURE 3. 500 MHz Oscillator Circuit

National Semiconductor

Process 43
NPN VHF/UHF Oscillator



TL/G/10037-39

DESCRIPTION

Process 43 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device was designed for use as RF amplifiers, oscillators and multipliers with collector current in the 1 mA to 20 mA range.

PRINCIPAL DEVICE TYPES

TO-72: 2N918

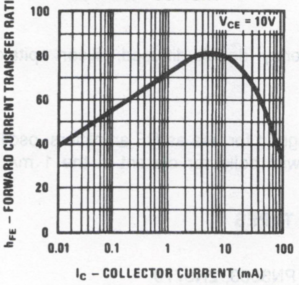
TO-92 EBC: PN918, PN3563, 2N5770

TO-236: MMBT918

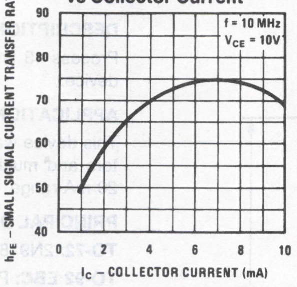
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
G_{PE}	f = 200 MHz, $I_C = 5$ mA, $V_{CE} = 10V$ (Neutralized)	14	18		dB
NF	f = 60 MHz, $I_C = 1$ mA, $V_{CE} = 10V$, $R_S = 200\Omega$		3.5	6.0	dB
PO	f = 500 MHz, $I_C = 8$ mA, $V_{CE} = 15V$ *(Figure 1)*	20	35		mW
	f = 900 MHz, $I_C = 8$ mA, $V_{CE} = 15V$	3.0	8.0		
h_{fe}	$I_C = 5$ mA, $V_{CE} = 10V$, f = 100 MHz	6.0	9.0		
rb'Cc	f = 79.8 MHz, $V_{CE} = 10V$, $I_E = 8$ mA		10	25	ps
C_{CB}	$V_{CB} = 10V$, $I_E = 0$		1.2	1.7	pF
C_{EB}	$V_{EB} = 0.5V$, $I_C = 0$		1.4	2.0	pF
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	25			
	$I_C = 5$ mA, $V_{CE} = 10V$	40	80	200	
	$I_C = 30$ mA, $V_{CE} = 10V$	30			
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.25		V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.9		V
BV_{CEO}	$I_C = 3$ mA	15			V
BV_{CBO}	$I_C = 10\ \mu A$	30			V
BV_{EBO}	$I_E = 10\ \mu A$	4			V
I_{CBO}	$V_{CB} = 20V$			100	nA
I_{EBO}	$V_{CB} = 3V$			100	nA

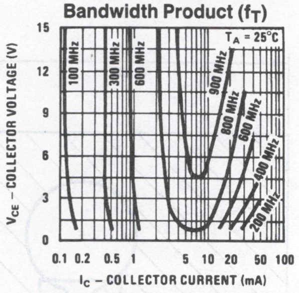
DC Current Gain vs Collector Current



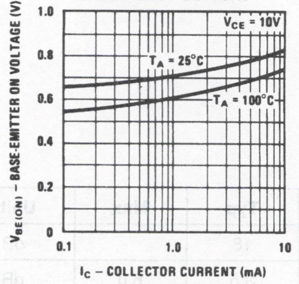
Small Signal Current Gain vs Collector Current



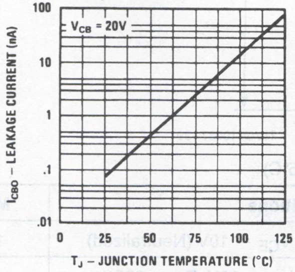
Contours of Constant Gain Bandwidth Product (f_T)



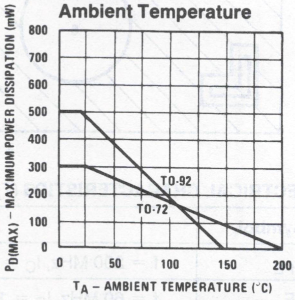
Base-Emitter ON Voltage vs Collector Current



Collector-Base Diode Reverse Current vs Temperature



Maximum Power Dissipation vs Ambient Temperature



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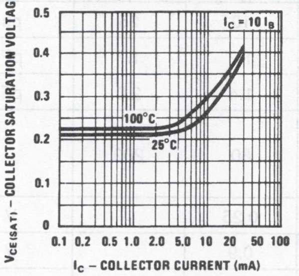
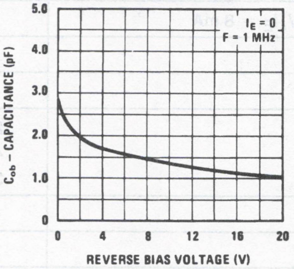
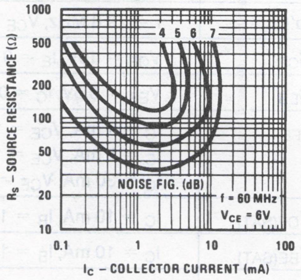
Collector Saturation Voltage vs Collector Current



Output Capacitance vs Reverse Bias Voltage



Contours of Constant Noise Figure

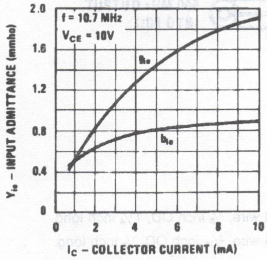


TL/G/10037-41

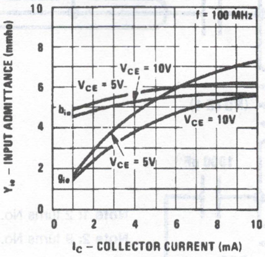
Process 43

COMMON EMITTER Y PARAMETERS VS FREQUENCY

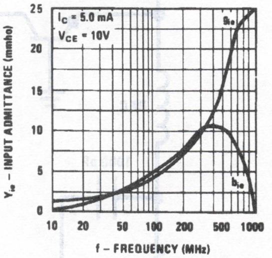
Input Admittance vs Collector Current-Output Short Circuit



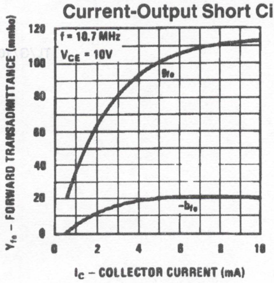
Input Admittance vs Collector Current-Output Short Circuit



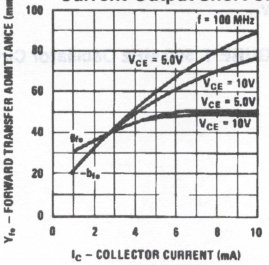
Input Admittance vs Frequency-Output Short Circuit



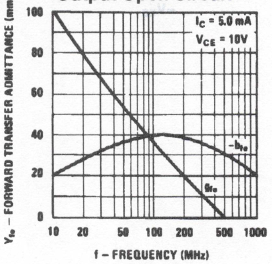
Forward Transfer Admittance vs Collector Current-Output Short Circuit



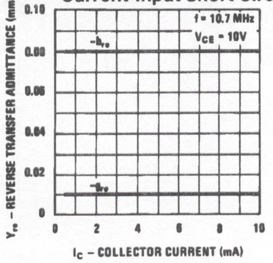
Forward Transfer Admittance vs Collector Current-Output Short Circuit



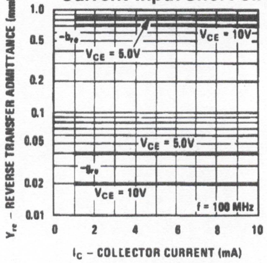
Forward Transfer Admittance vs Frequency-Output Open Circuit



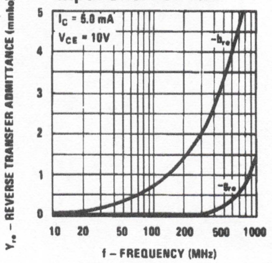
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



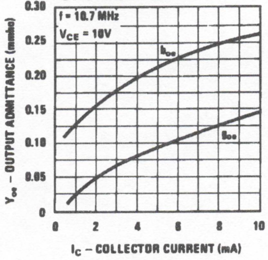
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



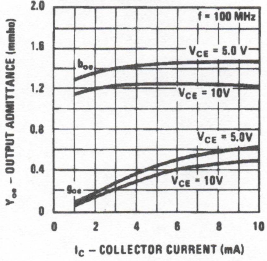
Reverse Transfer Admittance vs Frequency-Input Short Circuit



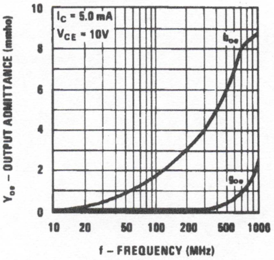
Output Admittance vs Collector Current-Input Short Circuit



Output Admittance vs Collector Current-Input Short Circuit

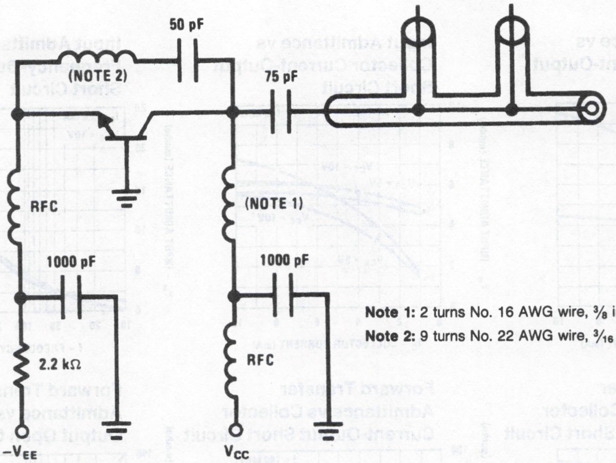


Output Admittance vs Frequency-Input Short Circuit



TL/G/10037-43

Process 43


50 pF
(NOTE 2)
75 pF
500 MHz OUTPUT INTO 50Ω
RFC
(NOTE 1)
1000 pF
1000 pF
2.2 kΩ
RFC
$-V_{EE}$
V_{CC}

Note 1: 2 turns No. 16 AWG wire, ⅜ inch OD, 1¼ inch long.

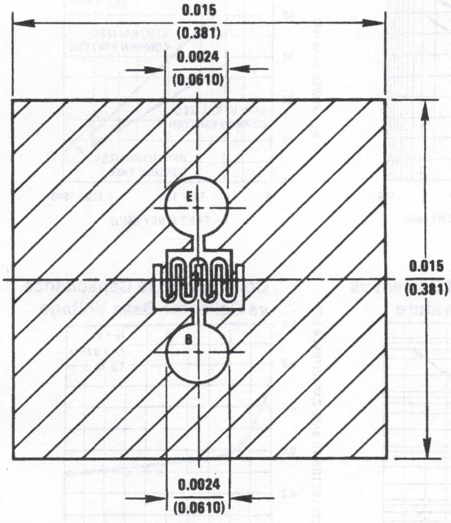
Note 2: 9 turns No. 22 AWG wire, ³⁄₁₆ inch OD, ½ inch long.

TL/G/10037-42

FIGURE 1. 500 MHz Oscillator Circuit

National Semiconductor

Process 44
NPN AGC-RF Amplifier



TL/G/10037–44

DESCRIPTION

Process 44 is an overlay, double-diffused, silicon device.

APPLICATION

This device was designed for use as a low noise VHF amplifier with forward AGC capability.

PRINCIPAL DEVICE TYPES

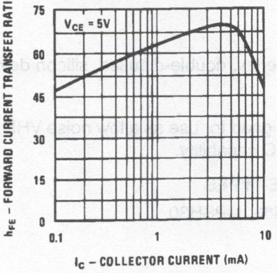
TO-92 BEC: MPS6568, MPSH30

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

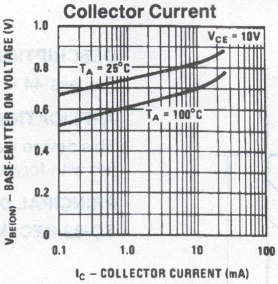
Symbol	Conditions	Min	Typ	Max	Units
NF	f = 200 MHz, $I_C = 2$ mA, $V_{CE} = 10V$, $R_S = 50\Omega$ *(Figure 1)*		2.0	3.0	dB
P_G	f = 200 MHz, $I_C = 2$ mA, $V_{CE} = 10V$, $R_S = 50\Omega$ *(Figure 1)*	20	24		dB
NF	f = 45 MHz, $I_C = 4$ mA, $V_{CE} = 10V$, $R_S = 50\Omega$ *(Figure 2)*		3.0	5.0	dB
P_G	f = 45 MHz, $I_C = 4$ mA, $V_{CE} = 10V$, $R_S = 50\Omega$ *(Figure 2)*	23	26		dB
AGC	f = 200 MHz, V_{AGC} at 30 dB Down *(Figure 1)* f = 45 MHz, V_{AGC} at 30 dB Down *(Figure 2)*	3.9 4.0	4.5 5.0	5.2 6.0	V
C_{cb}	$V_{CB} = 10V$, $I_E = 0$ (TO-72) (TO-92)		0.35 0.45	0.50 0.55	pF pF
h_{fe}	$V_{CE} = 10V$, $I_C = 4$ mA, f = 100 MHz	4.0	5.5		
h_{FE}	$I_C = 4$ mA, $V_{CE} = 5V$	30	70	200	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 5$ mA		0.5	2.0	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 5$ mA		0.85	0.95	V
BV_{CEO}	$I_C = 1$ mA	30			V
BV_{CBO}	$I_C = 10\ \mu A$	30			V
BV_{EBO}	$I_E = 10\ \mu A$	4.0			V
I_{CBO}	$V_{CB} = 20V$			100	nA
I_{EBO}	$V_{EB} = 3V$			100	nA

Process 44

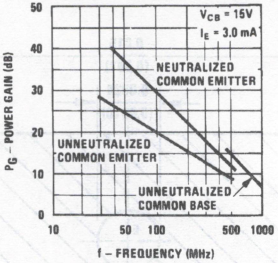
Pulsed DC Current Gain vs Collector Current



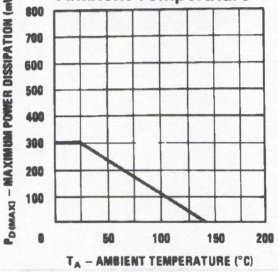
Base-Emitter ON Voltage vs Collector Current



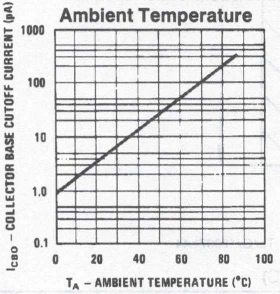
Power Gain vs Frequency



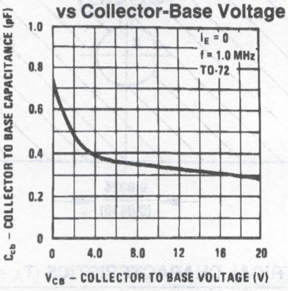
Maximum Power Dissipation vs Ambient Temperature



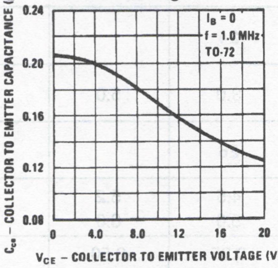
Collector Cutoff Current vs Ambient Temperature



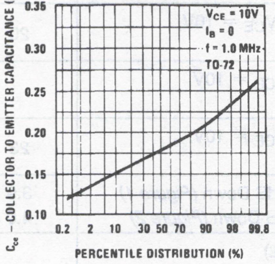
Collector-Base Capacitance vs Collector-Base Voltage



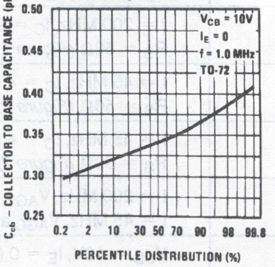
Collector-Emitter Capacitance vs Collector-Emitter Voltage



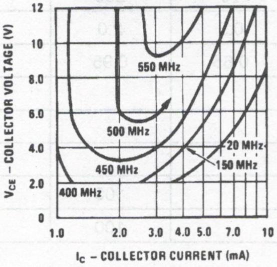
Distribution of Collector-Emitter Capacitance



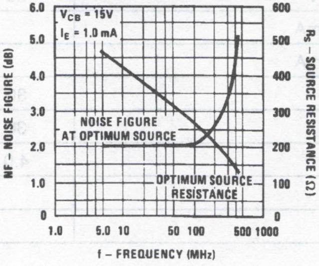
Distribution of Collector-Base Capacitance



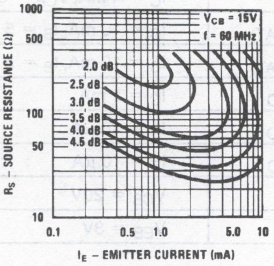
Contours of Constant Gain Bandwidth Product (f_T)



Noise Figure and Source Resistance vs Frequency



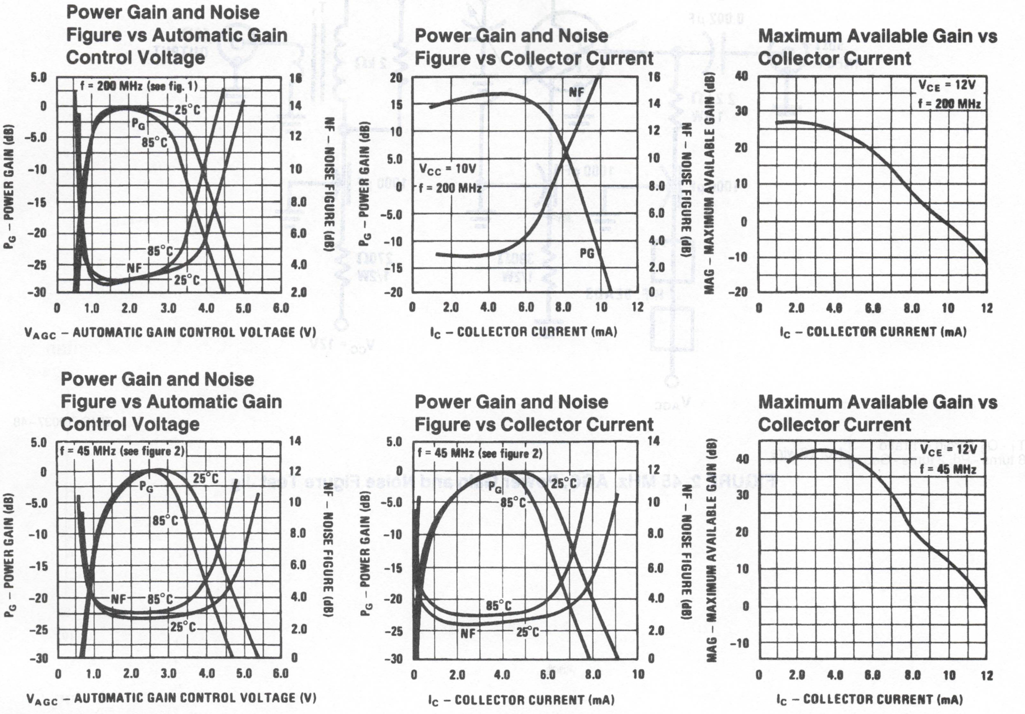
Noise Figure vs Source Resistance and Collector Current



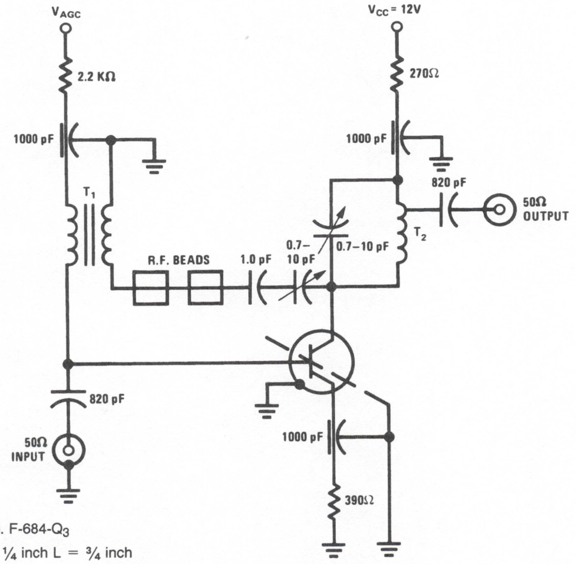
TL/G/10037-45

Process 44

COMMON EMITTER PERFORMANCE



TL/G/10037-46

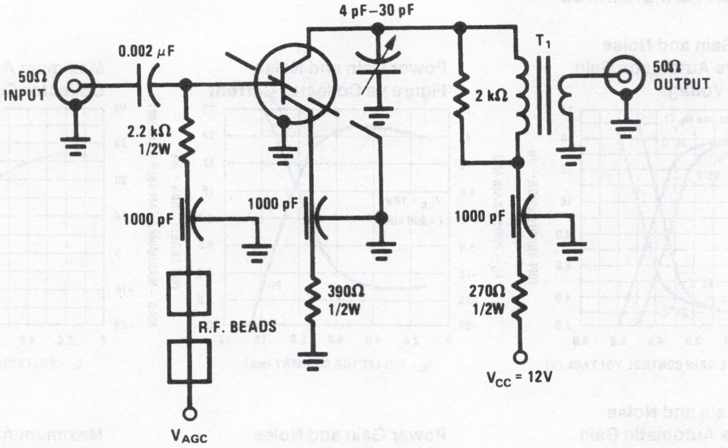

V_{AGC}
2.2 KΩ
1000 pF
T_1
R.F. BEADS
1.0 pF
0.7–10 pF
0.7–10 pF
820 pF
50Ω INPUT
V_{CC} = 12V
270Ω
1000 pF
820 pF
50Ω OUTPUT
T_2
1000 pF
390Ω

T_1 - Ferrite Core Indiana Gen. Corp. F-684-Q_3

T_2 - 6 turns No. 16 buss wire ID = ¼ inch L = ¾ inch

TL/G/10037-47

FIGURE 1. 200 MHz, AGC, Power Gain and Noise Figure Test Jig


4 pF–30 pF
0.002 μF
50Ω
INPUT
T₁
50Ω
OUTPUT
2.2 kΩ
1/2W
2 kΩ
1000 pF
1000 pF
1000 pF
390Ω
1/2W
270Ω
1/2W
R.F. BEADS
V_{CC} = 12V
V_{AGC}

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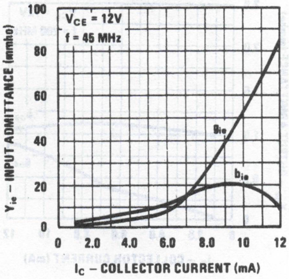
T_1 - Q_3 Toroid 4:1 ratio
8 turns - Pri. 2 turns - Sec. } No. 22 wire

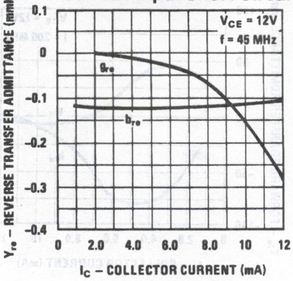
FIGURE 2. 45 MHz, AGC, Power Gain and Noise Figure Test Jig

COMMON EMITTER Y PARAMETERS VS FREQUENCY

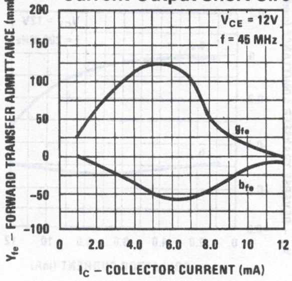
Input Admittance vs Collector Current-Output Short Circuit



Reverse Transfer Admittance vs Collector Current-Input Short Circuit

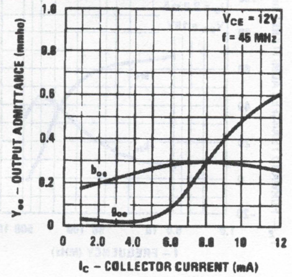


Forward Transfer Admittance vs Collector Current-Output Short Circuit

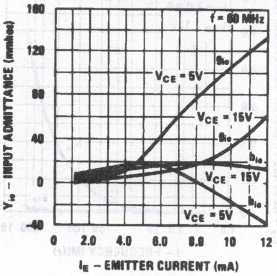


TL/G/10037-49

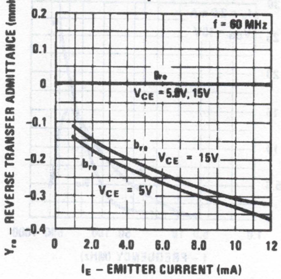
Output Admittance vs Collector Current-Input Short Circuit



Input Admittance vs Emitter Current-Output Short Circuit

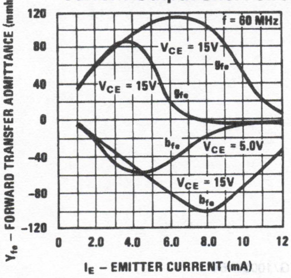


Reverse Transfer Admittance vs Emitter Current-Input Short Circuit

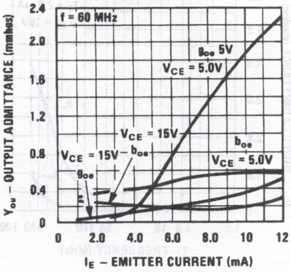


TL/G/10037-50

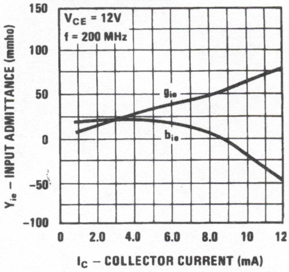
Forward Transfer Admittance vs Emitter Current-Output Short Circuit



Output Admittance vs Emitter Current-Input Short Circuit



Input Admittance vs Collector Current-Output Short Circuit



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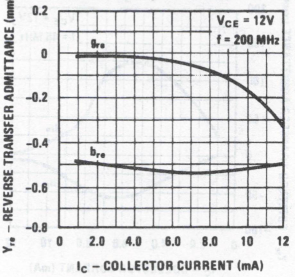
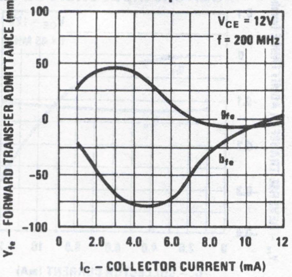
COMMON EMITTER Y PARAMETERS VS FREQUENCY (Continued)

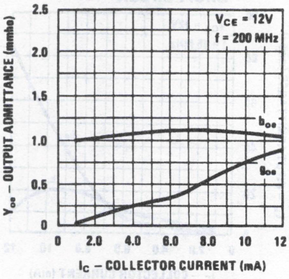
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



Forward Transfer Admittance vs Collector Current-Output Short Circuit

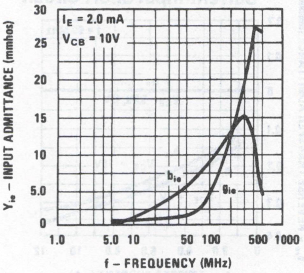


Output Admittance vs Collector Current-Input Short Circuit

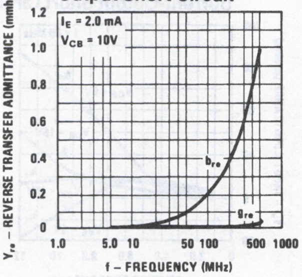


TL/G/10037–52

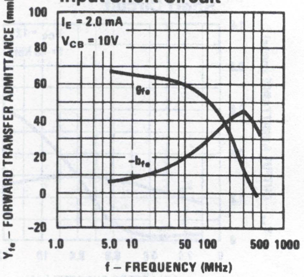
Input Admittance vs Frequency-Output Short Circuit



Reverse Transfer Admittance vs Frequency-Output Short Circuit

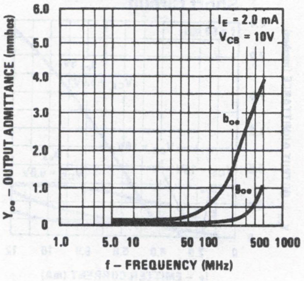


Forward Transfer Admittance vs Frequency-Input Short Circuit



TL/G/10037–53

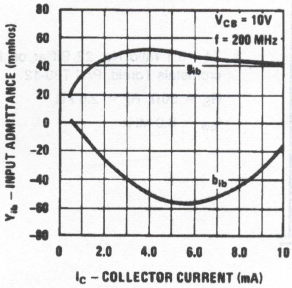
Output Admittance vs Frequency-Input Short Circuit



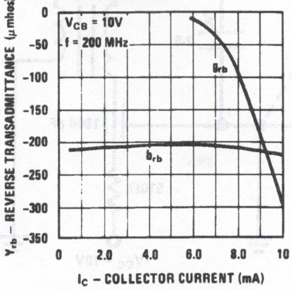
TL/G/10037–54

COMMON BASE Y PARAMETERS VS FREQUENCY

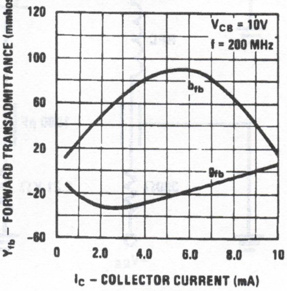
Input Admittance vs Collector Current-Output Short Circuit



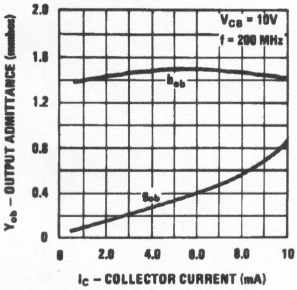
Reverse Transadmittance vs Collector Current-Input Short Circuit



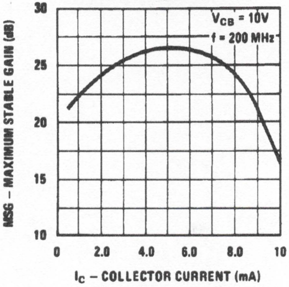
Forward Transadmittance vs Collector Current-Output Short Circuit



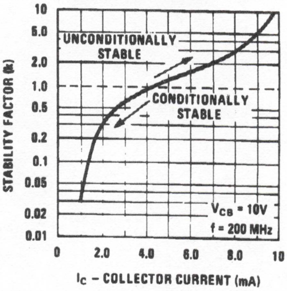
Output Admittance vs Collector Current-Input Short Circuit



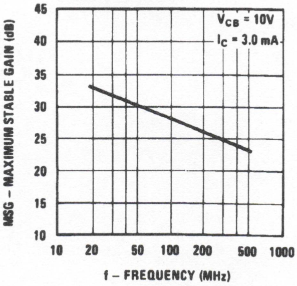
Maximum Stable Gain vs Collector Current Common Base Configuration



Common Base Configuration Stability Factor-k vs Collector Current



Maximum Stable Gain vs Frequency Common Base Configuration



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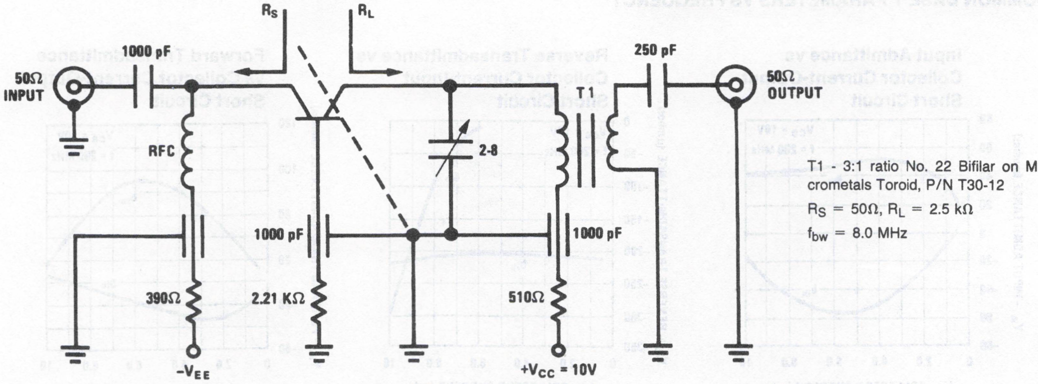
Process 44


R_S
R_L
1000 pF
50Ω
INPUT
RFC
390Ω
-V_EE
1000 pF
2.21 KΩ
2-8
250 pF
T1
1000 pF
510Ω
+V_CC = 10V
50Ω
OUTPUT

T1 - 3:1 ratio No. 22 Bifilar on Microcmetals Toroid, P/N T30-12

$R_S = 50\Omega$, $R_L = 2.5\ k\Omega$

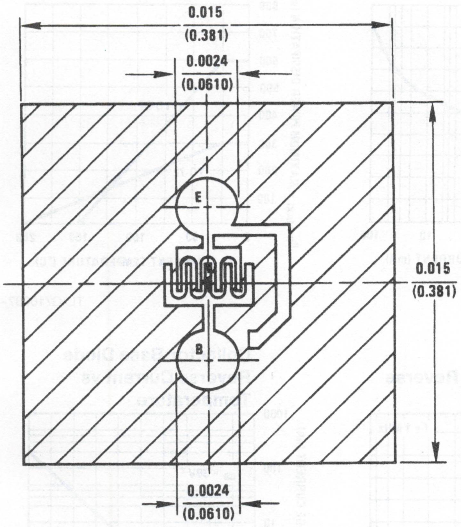
$f_{bw} = 8.0$ MHz

TL/G/10037-56

FIGURE 3. 200 MHz Common Base Power Gain, Noise Figure, Automatic Gain Control Test Circuit

National Semiconductor

Process 47
NPN RF-IF Amplifier



TL/G/10037-57

DESCRIPTION

Process 47 is an overlay, double-diffused, silicon epitaxial device, with a Faraday shield diffusion.

APPLICATION

This device was designed for common-emitter low noise amplifier and mixer applications in the 100 μA to 15 mA range to 300 MHz, and low frequency drift common-base VHF oscillator applications with high output levels for driving FET mixers.

PRINCIPAL DEVICE TYPES

TO-92 BEC: MPSH11, MPSH24

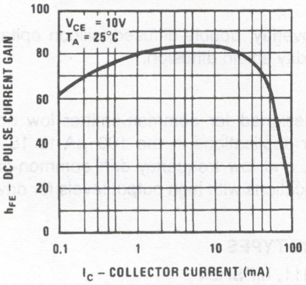
TO-237: MMBTH11

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

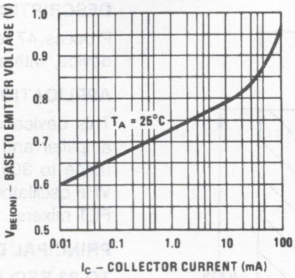
Symbol	Conditions	Min	Typ	Max	Units
P_G	f = 45 MHz, V_{CE} = 10V, I_C = 4 mA *(Figure 1)*	29	33		dB
P_G	f = 200 MHz, V_{CE} = 10V, I_C = 2 mA Unneutralized *(Figure 3)*	17	19.5		dB
NF	f = 200 MHz, V_{CE} = 10V, I_C = 2 mA, R_S = 50Ω *(Figure 3)*		2.0	3.5	dB
rb′Cc	f = 79.8 MHz, V_{CB} = 10V, I_E = 5 mA			15.0	ps
h_{fe}	f = 100 MHz, V_{CE} = 15V, I_C = 7 mA	6	10		
C_{ib}	V_{EB} = 0.5V, I_C = 0 (TO-92)		2.0	3.0	pF
C_{CB}	V_{CB} = 10V, I_E = 0 (TO-92)		0.33	0.40	pF
g_{oe}	f = 45 MHz, V_{CE} = 15V, I_C = 7 mA			125	μmho
roep	f = 10.7 MHz, V_{CE} = 10V, I_C = 2 mA	100k			Ω
h_{FE}	V_{CE} = 15V, I_C = 7 mA	40	100	200	
$V_{CE(SAT)}$	I_C = 20 mA, I_B = 1 mA		0.3	1.0	V
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 5 mA			0.95	V
BV_{CEO}	I_C = 1 mA	35			V
BV_{CBO}	I_C = 10 μA	40			V
BV_{EBO}	I_E = 10 μA	4.0			V
I_{CBO}	V_{CB} = 30V			100	nA
I_{EBO}	V_{EB} = 3V			100	nA

Process 47

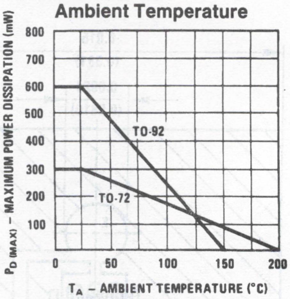
DC Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current



Maximum Power Dissipation vs Ambient Temperature



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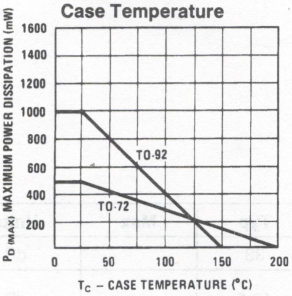
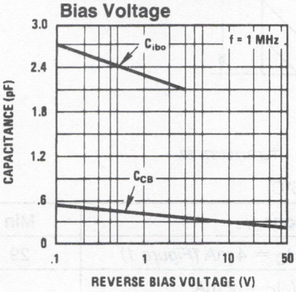
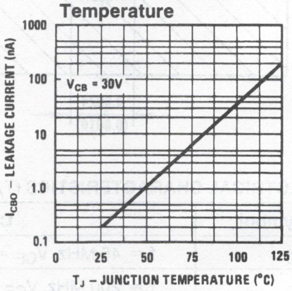
Maximum Power Dissipation vs Case Temperature



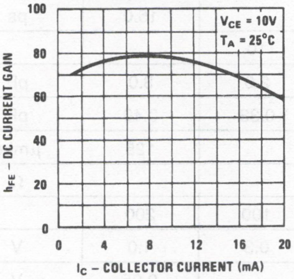
Capacitance vs Reverse Bias Voltage



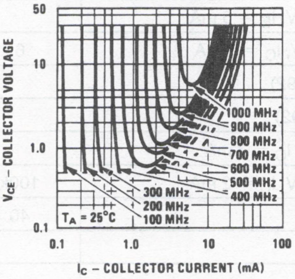
Collector-Base Diode Reverse Current vs Temperature



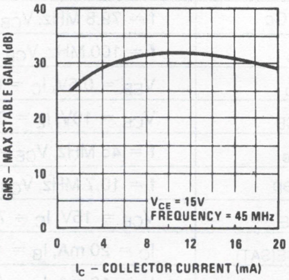
DC Current Gain vs Collector Current



Contours of Constant Gain Bandwidth Product (f_T)



Maximum Stable Gain vs Collector Current



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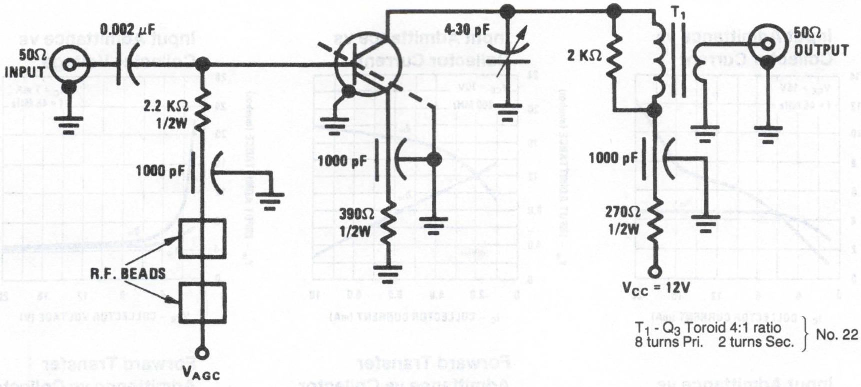
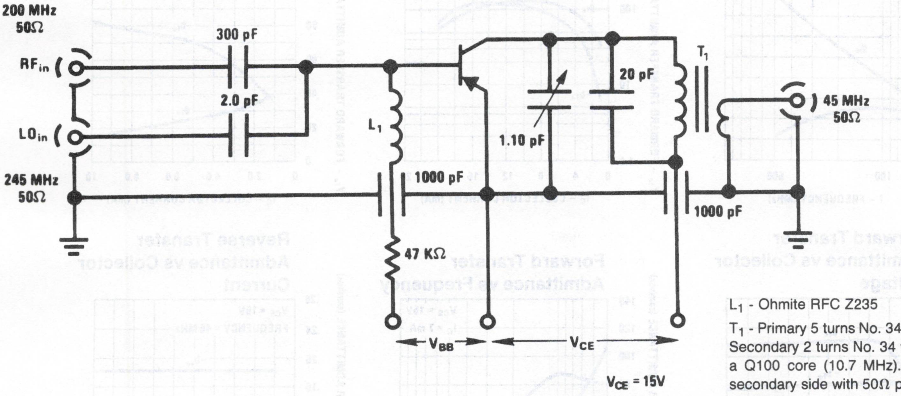
Process 47


0.002 µF
50Ω
INPUT
2.2 KΩ
1/2W
1000 pF
R.F. BEADS
V_AGC
4-30 pF
1000 pF
390Ω
1/2W
2 KΩ
T₁
50Ω
OUTPUT
1000 pF
270Ω
1/2W
V_CC = 12V

T₁ - Q₃ Toroid 4:1 ratio
8 turns Pri. 2 turns Sec. } No. 22 wire

TL/G/10037-58

FIGURE 1. 45 MHz Power Gain Circuit


200 MHz
50Ω
RF_in
300 pF
2.0 pF
LO_in
245 MHz
50Ω
L₁
1000 pF
47 KΩ
V_BB
V_CE
1.10 pF
20 pF
T₁
45 MHz
50Ω
1000 pF
V_CE = 15V

L₁ - Ohmite RFC Z235

T₁ - Primary 5 turns No. 34 wire ¼ inch diameter. Secondary 2 turns No. 34 wire close wound over a Q100 core (10.7 MHz). When terminated on secondary side with 50Ω primary measures 1.5k, −25 pF.

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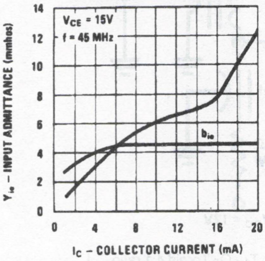
FIGURE 2. 200 MHz Conversion Gain Test Circuit

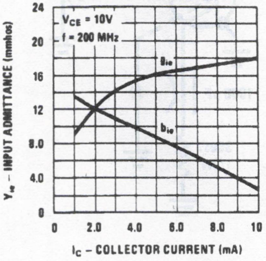
Process 47

COMMON-EMITTER Y PARAMETERS

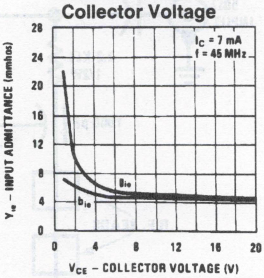
Input Admittance vs Collector Current



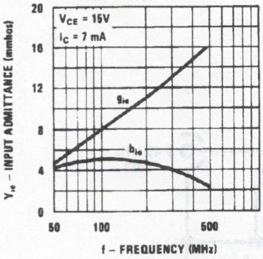
Input Admittance vs Collector Current



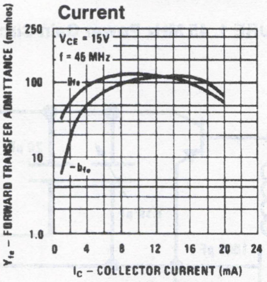
Input Admittance vs Collector Voltage



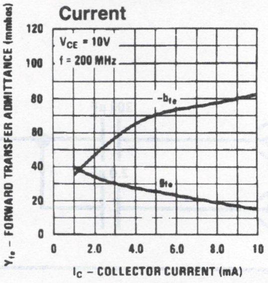
Input Admittance vs Frequency



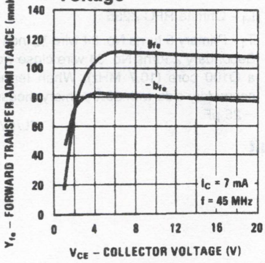
Forward Transfer Admittance vs Collector Current



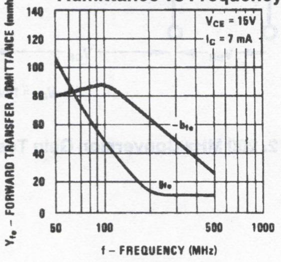
Forward Transfer Admittance vs Collector Current



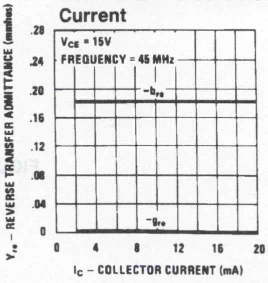
Forward Transfer Admittance vs Collector Voltage



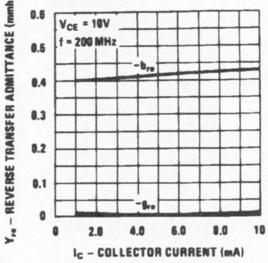
Forward Transfer Admittance vs Frequency



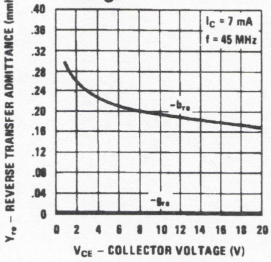
Reverse Transfer Admittance vs Collector Current



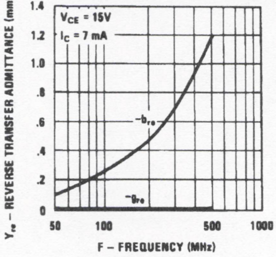
Reverse Transfer Admittance vs Collector Current



Reverse Transfer Admittance vs Collector Voltage



Reverse Transfer Admittance vs Frequency



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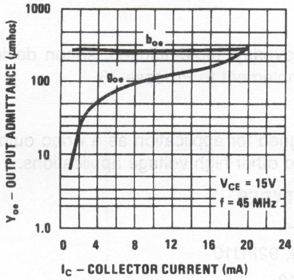
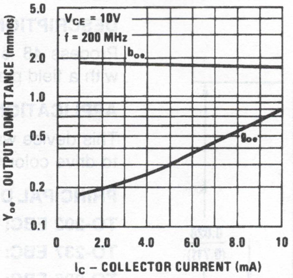
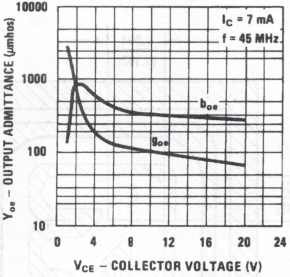
Process 47



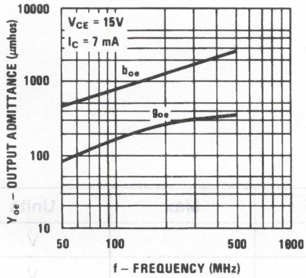
Output Admittance vs Collector Current



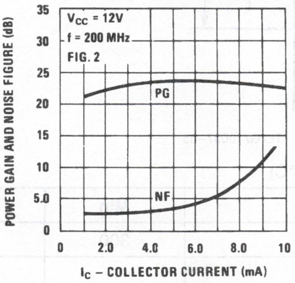
Output Admittance vs Collector Current



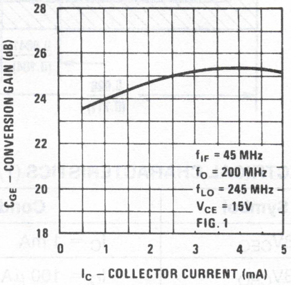
Output Admittance vs Collector Voltage



Output Admittance vs Frequency

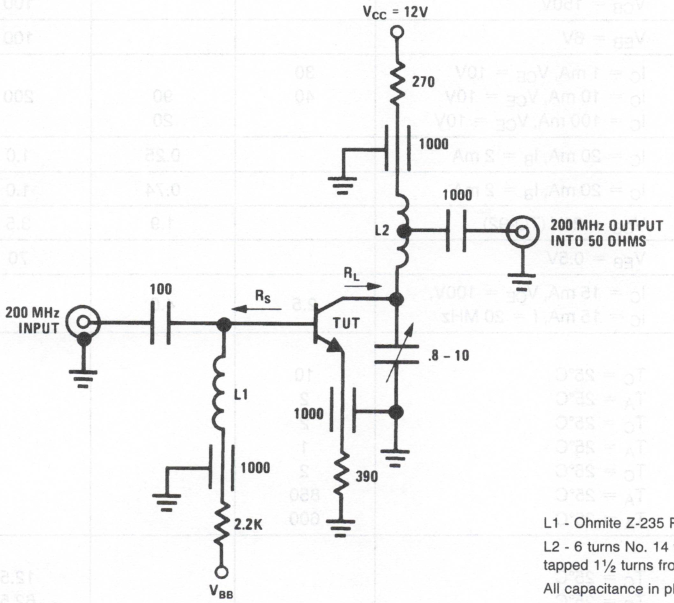


Power Gain and Noise Figure vs Collector Current



Conversion Gain vs Collector Current

TL/G/10037-63



V_{CC} = 12V
270
1000
1000
L2
200 MHz OUTPUT INTO 50 OHMS
R_L
R_S
100
200 MHz INPUT
TUT
.8 – 10
L1
1000
1000
390
2.2K
V_{BB}

L1 - Ohmite Z-235 RFC

L2 - 6 turns No. 14 wire, 1 inched L x ¼ inch ID tapped 1½ turns from cold side

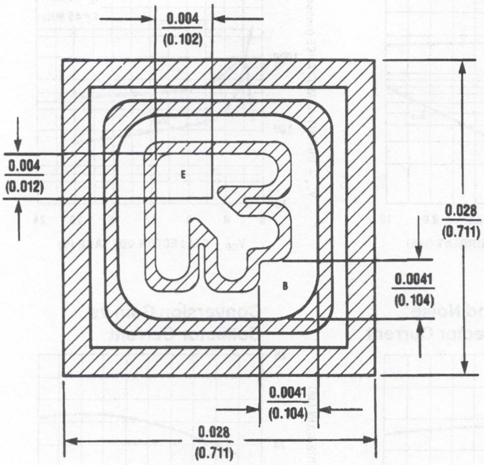
All capacitance in pF, all resistance in Ω.

TL/G/10037-64

FIGURE 3. Unneutralized 200 MHz PG NF Test Circuit

National Semiconductor

Process 48
NPN High Voltage Amplifier



TL/G/10037-65

DESCRIPTION

Process 48 is a non-overlay, triple-diffused, silicon device with a field plate. Complement to Process 76.

APPLICATION

This device was designed for application as a video output to drive color CRT and other high voltage applications.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D40N1-4
TO-237 EBC: 2N6719, 92PU10
TO-226 EBC: MPSW42
TO-92 EBC: MPSA42

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

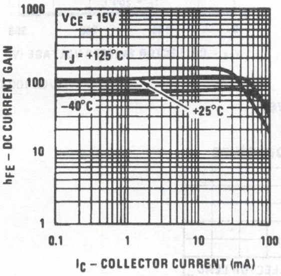
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1$ mA	300	370		V
BV_{CBO}	$I_C = 100\ \mu A$		500		V
BV_{EBO}	$I_E = 10\ \mu A$	7.0			V
I_{CES}	$V_{CB} = 150V$			100	nA
I_{EBO}	$V_{EB} = 6V$			100	nA
h_{FE}	$I_C = 1$ mA, $V_{CE} = 10V$	30			
	$I_C = 10$ mA, $V_{CE} = 10V$	40	90	200	
	$I_C = 100$ mA, $V_{CE} = 10V$		20		
$V_{CE(SAT)}$	$I_C = 20$ mA, $I_B = 2$ mA		0.25	1.0	V
$V_{BE(SAT)}$	$I_C = 20$ mA, $I_B = 2$ mA		0.74	1.0	V
C_{CB}	$V_{CB} = 20V$ (TO-92)		1.9	3.5	pF
C_{ib}	$V_{EB} = 0.5V$			70	pF
h_{fe}	$I_C = 15$ mA, $V_{CE} = 100V$, $I_C = 15$ mA, f = 20 MHz	2.5	4.0		
$P_{D(max)}$					
TO-202	$T_C = 25°C$	10			W
	$T_A = 25°C$	2			W
TO-226	$T_C = 25°C$	2			W
	$T_A = 25°C$	1			W
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_C = 25°C$			62.5	°C/W

Process 48

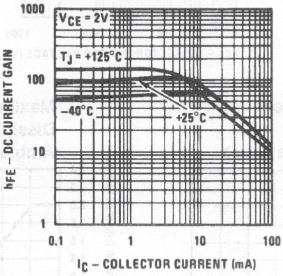
ELECTRICAL CHARACTERISTICS (T_A = 25°C) (Continued)

Symbol	Conditions	Min	Typ	Max	Units
θ_{JA}					
TO-202	T_A = 25°C			62.5	°C/W
TO-226	T_A = 25°C			125	°C/W
TO-237	T_A = 25°C			147	°C/W
TO-92	T_A = 25°C			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

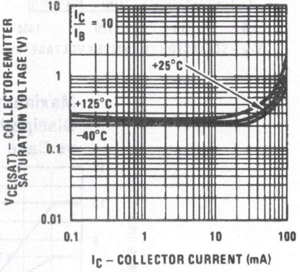
DC Current Gain vs Collector Current



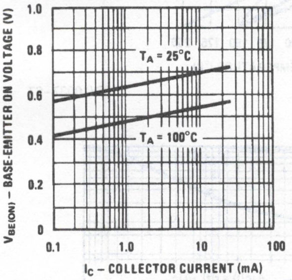
Typical Pulsed Current Gain vs Collector Current



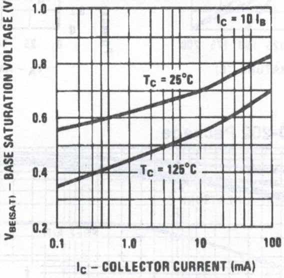
Collector-Emitter Saturation Voltage vs Collector Current



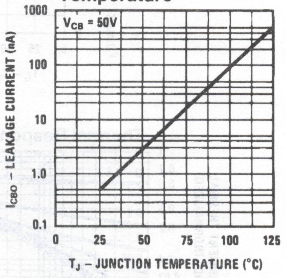
Base-Emitter ON Voltage vs Collector Current



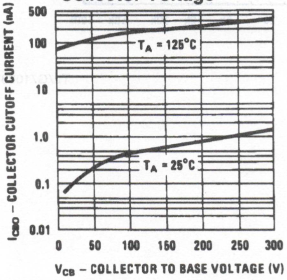
Base Saturation Voltage vs Collector Current



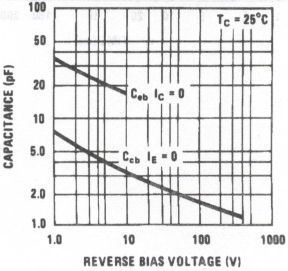
Collector-Base Diode Reverse Current vs Temperature



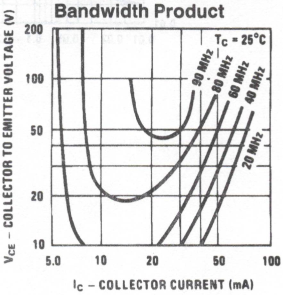
Collector Cutoff Current vs Collector Voltage



Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage

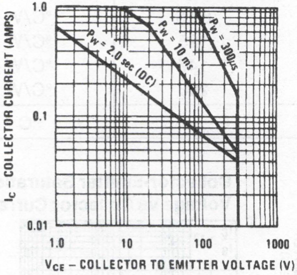


Contours of Constant Gain Bandwidth Product

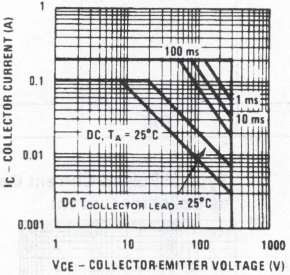


TL/G/10037-66

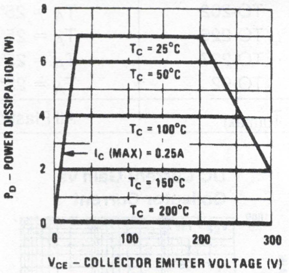
Safe Operating Area TO-202



Safe Operating Area TO-237

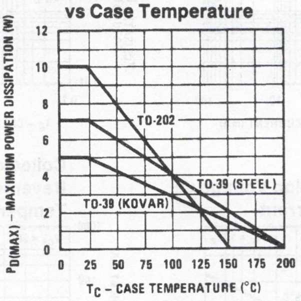


Guaranteed Maximum DC Power Dissipation vs Collector-Emitter Voltage TO-39

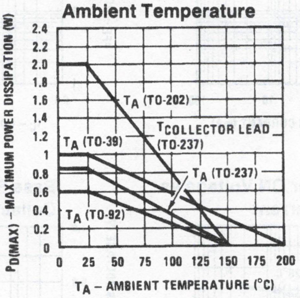


TL/G/10037-75

Maximum Power Dissipation vs Case Temperature

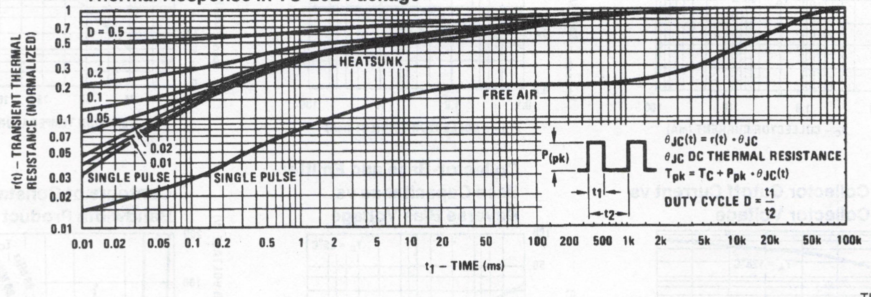


Maximum Power Dissipation vs Ambient Temperature



TL/G/10037-67

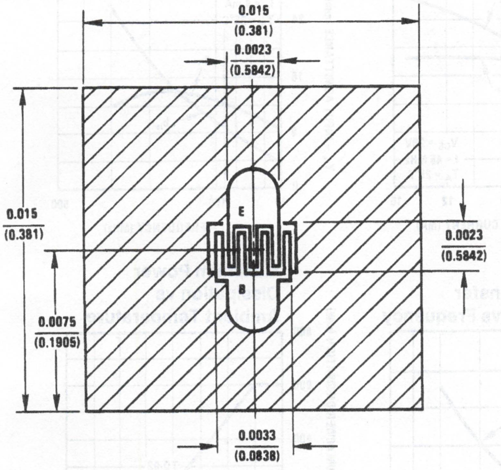
Thermal Response in TO-202 Package



TL/G/10037-68

National Semiconductor

Process 49
NPN RF Amplifier



TL/G/10037-69

DESCRIPTION

Process 49 is an overlay, double-diffused, silicon epitaxial device.

APPLICATION

This device was designed for general RF amplifier and mixer applications to 250 MHz with collector current in the 1 mA to 20 mA range.

PRINCIPAL DEVICE TYPES

TO-92 BEC: MPSH20

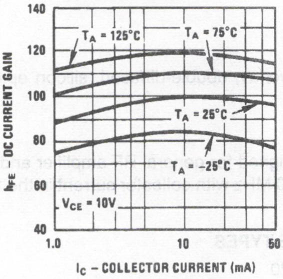
TO-236: MMBTH20

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

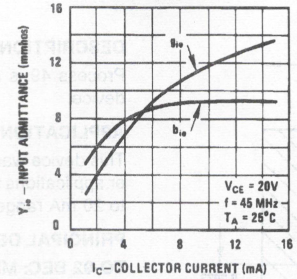
Symbol	Conditions	Min	Typ	Max	Units
P_G	f = 45 MHz, V_{CE} = 10V, I_C = 10 mA	25	30		dB
f_T	V_{CE} = 10V, I_C = 10 mA	400	700		MHz
rb′Cc	f = 79.8 MHz, V_{CE} = 10V, I_C = 8 mA			20.0	ps
C_{CB}	f = 1.0 MHz, V_{CB} = 10V, I_E = 0		0.55	0.65	pF
h_{FE}	V_{CE} = 10V, I_C = 10 mA V_{CE} = 10V, I_C = 4 mA	40 30	100	250	
$V_{BE(ON)}$	V_{CE} = 10V, I_C = 10 mA		0.80	0.90	V
$V_{CE(SAT)}$	I_C = 30 mA, I_C = 3 mA		0.15	0.50	V
roep	f = 4.5 MHz, V_{CE} = 10V, I_C = 2 mA	80k			Ω
BV_{CEO}	I_C = 1 mA	35			V
BV_{CBO}	I_C = 10 μA	45			V
BV_{EBO}	I_E = 10 μA	4.0			V
I_{CBO}	V_{CB} = 30V			100	nA
I_{EBO}	V_{EB} = 3.0V			100	nA

Process 49

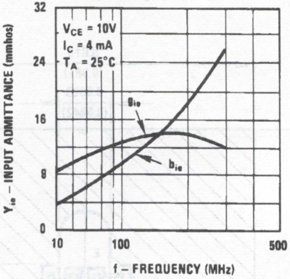
DC Current Gain vs Collector Current



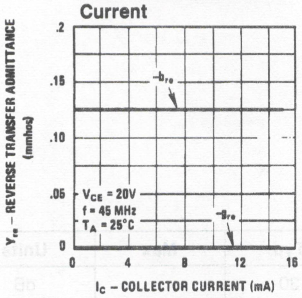
Input Admittance vs Collector Current



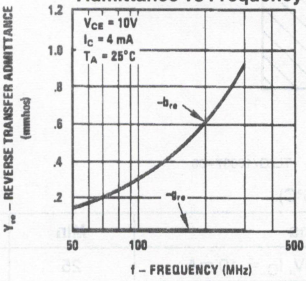
Input Admittance vs Frequency



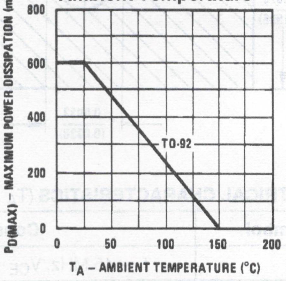
Reverse Transfer Admittance vs Collector Current



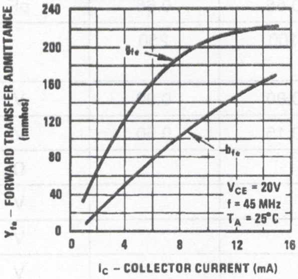
Reverse Transfer Admittance vs Frequency



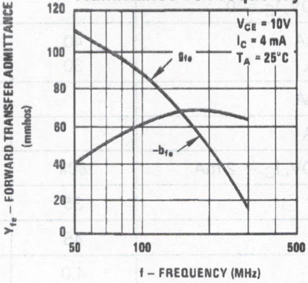
Maximum Power Dissipation vs Ambient Temperature



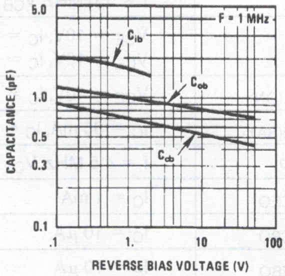
Forward Transfer Admittance vs Collector Current



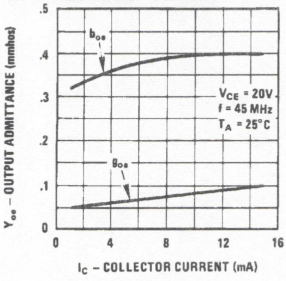
Forward Transfer Admittance vs Frequency



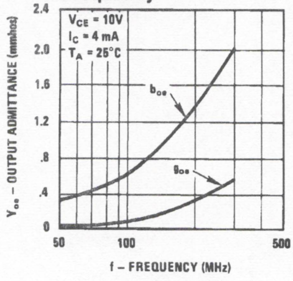
Capacitance vs Reverse Bias Voltage



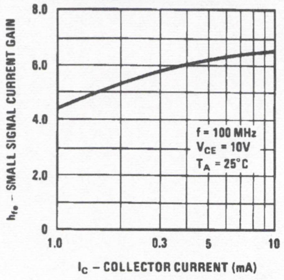
Output Admittance vs Collector Current



Output Admittance vs Frequency

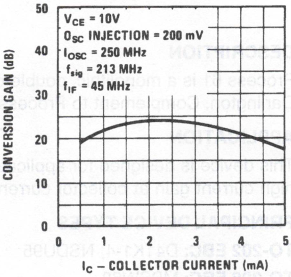


Small Signal Current Gain vs Collector Current

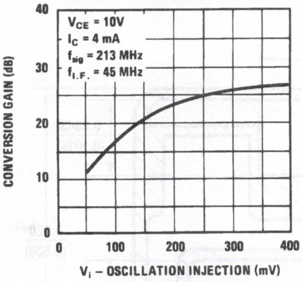


TL/G/10037-70

Process 49

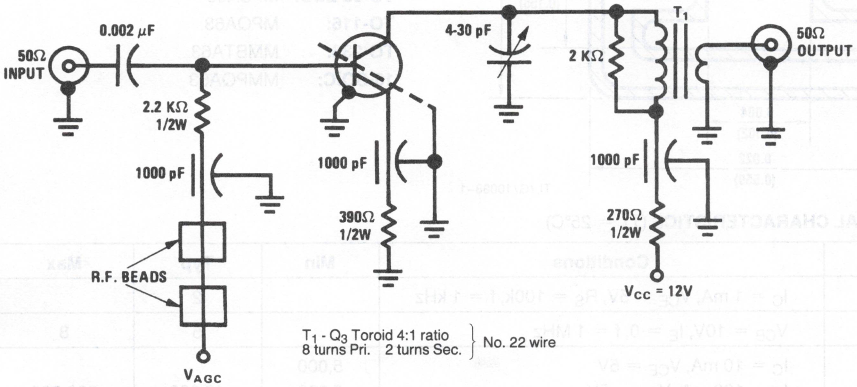


Conversion Gain vs Collector Current



Conversion Gain vs Oscillator Injection Level

TL/G/10037-71

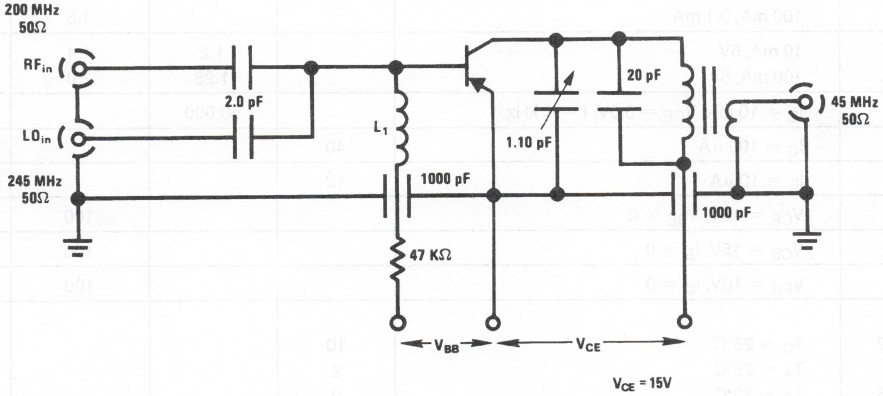


50Ω
INPUT
0.002 μF
2.2 KΩ
1/2W
1000 pF
R.F. BEADS
V_{AGC}
1000 pF
390Ω
1/2W
4-30 pF
2 KΩ
T_1
50Ω
OUTPUT
1000 pF
270Ω
1/2W
V_{CC} = 12V

T_1 - Q_3 Toroid 4:1 ratio
8 turns Pri. 2 turns Sec. } No. 22 wire

TL/G/10037-72

FIGURE 1. 45 MHz Power Gain Circuit



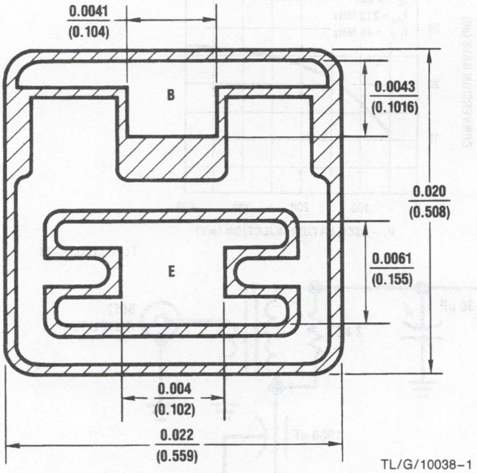
200 MHz
50Ω
RF_{in}
LO_{in}
245 MHz
50Ω
2.0 pF
L_1
1000 pF
47 KΩ
1.10 pF
20 pF
45 MHz
50Ω
1000 pF
V_{BB}
V_{CE}
V_{CE} = 15V

TL/G/10037-73

FIGURE 2. 200 MHz Conversion Gain Test Circuit

National Semiconductor

Process 61
PNP Darlington



TL/G/10038-1

DESCRIPTION

Process 61 is a monolithic, double-diffused, silicon epitaxial Darlington. Complement to Process 05.

APPLICATION

This device is designed for applications requiring extremely high current gain at collector currents to 1A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D41K1-4, NSDU95
TO-226 EBC: MPSW63
TO-92 EBC: MPSA63
TO-116: MPQA63
TO-236: MMBTA63
16-SOIC: MMPQA63

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

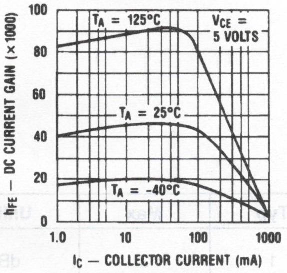
Symbol	Conditions	Min	Typ	Max	Units
NF	$I_C = 1$ mA, $V_{CE} = 5V$, $R_S = 100k$, f = 1 kHz		2		dB
C_{CB}	$V_{CB} = 10V$, $I_E = 0$, f = 1 MHz		5	8	pF
h_{FE}	$I_C = 10$ mA, $V_{CE} = 5V$ $I_C = 100$ mA, $V_{CE} = 5V$ $I_C = 1A$, $V_{CE} = 5V$	5,000 5,000 1,500	 40,000	 200,000	
$V_{CE(SAT)}$	10 mA, 0.01 mA 100 mA, 0.1 mA			1.0 1.5	V
$V_{BE(ON)}$	10 mA, 5V 100 mA, 5V		1.2 1.25	1.4 2.0	V
h_{fe}	$I_C = 10$ mA, $V_{CE} = 5.0V$, f = 1 kHz		50,000		
BV_{CES}	$I_C = 100\ \mu A$	40			V
BV_{EBO}	$I_E = 10\ \mu A$	12			V
I_{CES}	$V_{CE} = 15V$, $V_{BE} = 0$			100	nA
I_{CBO}	$V_{CB} = 15V$, $I_E = 0$			100	nA
I_{EBO}	$V_{EB} = 10V$, $I_C = 0$			100	nA
$P_{D(max)}$ TO-202 TO-226 TO-237 TO-92 TO-236	 $T_C = 25°C$ $T_A = 25°C$ $T_C = 25°C$ $T_A = 25°C$ $T_C = 25°C$ $T_A = 25°C$ $T_A = 25°C$ $T_C = 25°C$	 10 2 2 1 2 850 600 350			 W W W W W mW mW mW

Process 61

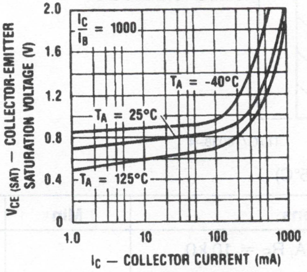
ELECTRICAL CHARACTERISTICS (T_A = 25°C) (Continued)

Symbol	Conditions	Min	Typ	Max	Units
θ_{JC}					
TO-202	T_C = 25°C			12.5	°C/W
TO-237	T_C = 25°C			62.5	°C/W
θ_{JA}					
TO-202	T_A = 25°C			62.5	°C/W
TO-226	T_A = 25°C			125	°C/W
TO-237	T_A = 25°C			147	°C/W
TO-92	T_A = 25°C			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

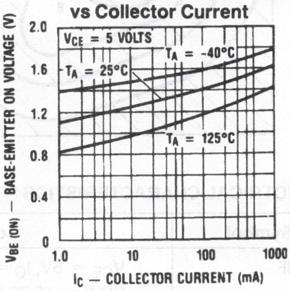
DC Current Gain vs Collector Current



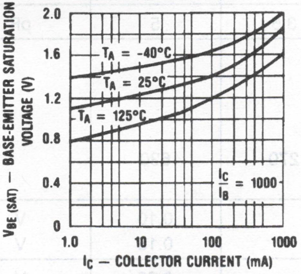
Collector Emitter Saturation Voltage vs Collector Current



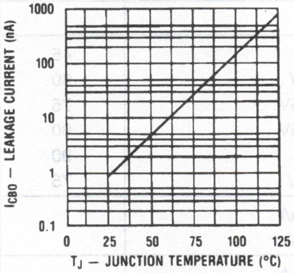
Base-Emitter ON Voltage vs Collector Current



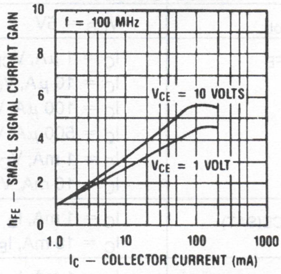
Base-Emitter Saturation Voltage vs Collector Currrent



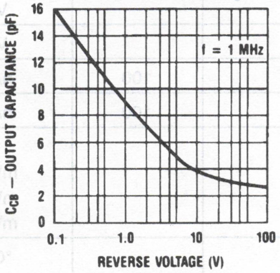
Collector-Base Diode Reverse Current vs Temperature



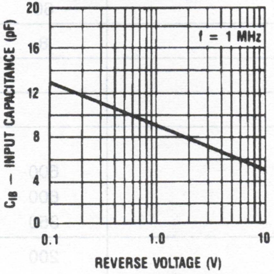
Small Signal Current Gain vs Collector Current



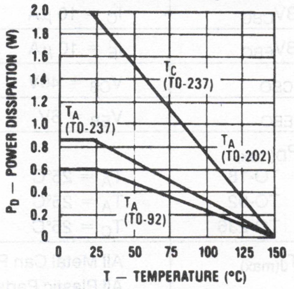
Output Capacitance vs Reverse Bias Voltage



Input Capacitance vs Reverse Voltage



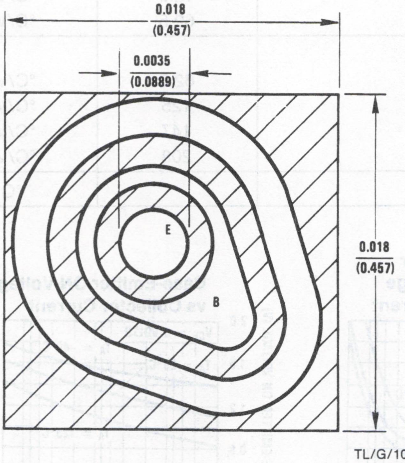
Thermal Derating Curve



TL/G/10038–2

National Semiconductor

Process 62
PNP Small Signal



TL/G/10038-4

DESCRIPTION

Process 62 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 07.

APPLICATION

These devices are designed for low level, high gain, low noise general purpose amplifier applications to 20 mA collector current.

PRINCIPAL DEVICE TYPES

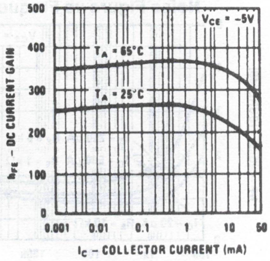
TO-18:	2N3550
TO-92 EBC:	2N5086, PN4250
TO-236:	MMBT5086

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

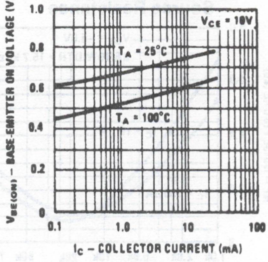
Symbol	Conditions	Min	Typ	Max	Units
NF	V_{CE} = 5V, I_C = 10 μA, R_S = 10 kΩ, PBW = 15.70 kHz		1	3	dB
h_{fe}	V_{CE} = 5V, I_C = 500 μA, f = 20 MHz	3	6		
C_{ib}	V_{EB} = 0.5V			8	pF
C_{ob}	V_{CB} = 5V		3.5	5	pF
h_{FE}	I_C = 1 μA, V_{CE} = 5V	45			
	I_C = 10 μA, V_{CE} = 5V	60			
	I_C = 100 μA, V_{CE} = 5V	75			
	I_C = 500 μA, V_{CE} = 5V	90			
	I_C = 1 mA, V_{CE} = 5V	90	270	630	
	I_C = 10 mA, V_{CE} = 5V	75			
$V_{CE(SAT)}$	I_C = 1 mA, I_B = 0.1 mA			0.10	V
	I_C = 10 mA, I_B = 1 mA			0.15	V
$V_{BE(SAT)}$	I_C = 1 mA, I_B = 0.1 mA			0.75	V
	I_C = 10 mA, I_B = 1 mA			0.90	V
BV_{CEO}	I_C = 1 mA	50			V
BV_{CBO}	I_C = 10 μA	60			V
BV_{EBO}	I_E = 10 μA	8			V
I_{CBO}	V_{CB} = 40V			100	nA
I_{EBO}	V_{EB} = 6V			100	nA
$P_{D(max)}$					
TO-18	T_A = 25°C	600			mW
TO-92	T_A = 25°C	600			mW
TO-236	T_C = 25°C	350			mW
$T_{J(max)}$	All Metal Can Parts	200			°C
	All Plastic Parts	150			°C

Process 62

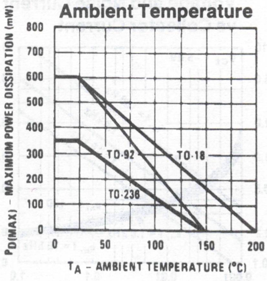
DC Current Gain vs Collector Current



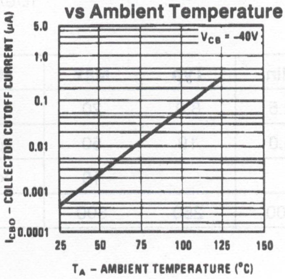
Base-Emitter ON Voltage vs Collector Current



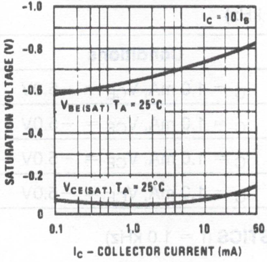
Maximum Power Dissipation vs Ambient Temperature



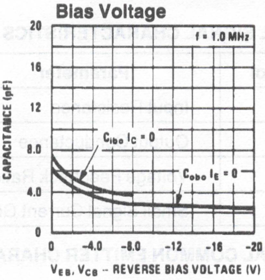
Collector Cutoff Current vs Ambient Temperature



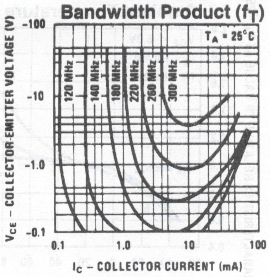
Collector and Base Saturation Voltage vs Collector Currrent



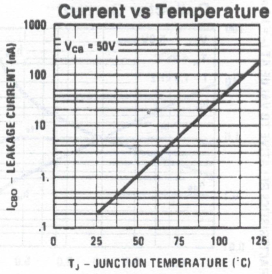
Input and Output Capacitance vs Reverse Bias Voltage



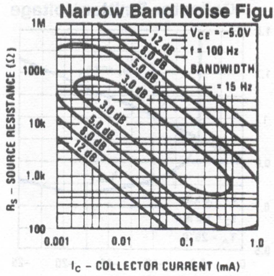
Contours of Constant Gain Bandwidth Product (f_T)



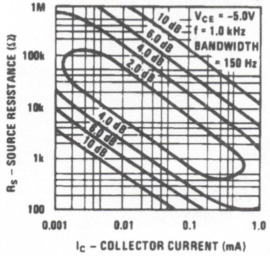
Collector-Base Diode Current vs Temperature



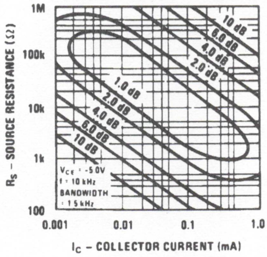
Contours of Constant Narrow Band Noise Figure



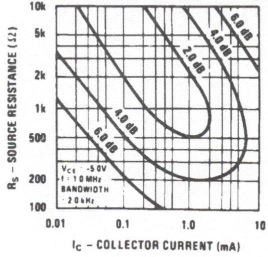
Contours of Constant Narrow Band Noise Figure



Contours of Constant Narrow Band Noise Figure

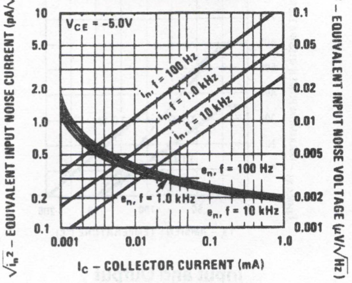


Contours of Constant Narrow Band Noise Figure

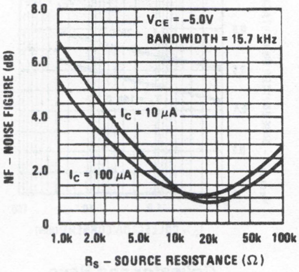


TL/G/10038–5

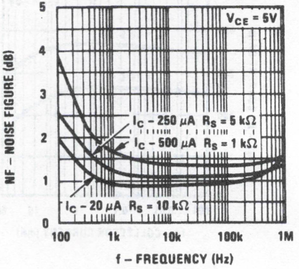
Process 62



Equivalent Input Noise Voltage and Noise Current vs Collector Current



Wideband Noise Figure vs Source Resistance



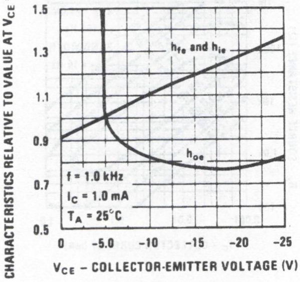
Noise Figure vs Frequency

TL/G/10038-6

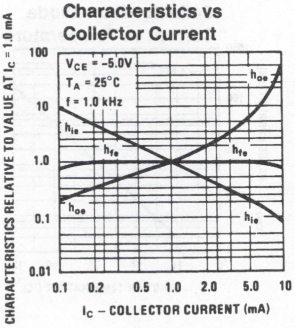
SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
h_{ie}	Input Resistance	$I_C = 1.0$ mA, $V_{CE} = -5.0$V	2.5	8.0	20	kΩ
h_{oe}	Output Conductance	$I_C = 1.0$ mA, $V_{CE} = -5.0$V	5.0	19	50	μmho
h_{re}	Voltage Feedback Ratio	$I_C = 1.0$ mA, $V_{CE} = -5.0$V			10	$\times 10^{-4}$
h_{fe}	Small Signal Current Gain	$I_C = 1.0$ mA, $V_{CE} = -5.0$V	100	250	800	

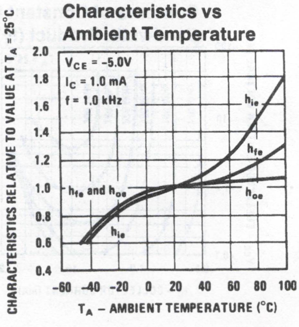
TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)



Common Emitter Characteristics vs Collector-Emitter Voltage



Common Emitter Characteristics vs Collector Current

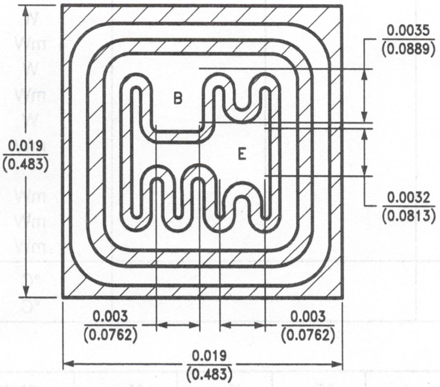


Common Emitter Characteristics vs Ambient Temperature

TL/G/10038-7

National Semiconductor

Process 63
PNP Medium Power



TL/G/10038–8

DESCRIPTION

Process 63 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 19.

APPLICATION

This device was designed for use as general purpose amplifiers and switches requiring collector currents to 500 mA.

PRINCIPAL DEVICE TYPES

TO-5 EBC:	2N2905
TO-18 EBC:	2N2907A
TO-237 EBC:	TN2905
TO-92 EBC:	PN2907A, 2N4403
TO-116:	MPQ2907
TO-236:	MMBT2907
16-SOIC:	MMPQ2907

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	$I_C = 150$ mA, $I_{B1} = 15$ mA *(Figure 1)*		30	45	ns
t_{OFF}	$I_C = 150$ mA, $I_{B2} = 15$ mA *(Figure 2)*		220	290	ns
C_{CB}	$V_{CB} = 10V$		6	8	pF
C_{EB}	$V_{EB} = 0.50V$			20	pF
h_{fe}	$I_C = 20$ mA, $V_{CE} = 20V$, f = 100 MHz	1.5	2.5		
NF(spot)	$I_C = 100\ \mu A$, $V_{CE} = 10V$, $R_S = 1k$, f = 1 kHz		1.5		dB
h_{FE}	$I_C = 1$ mA, $V_{CE} = 10V$	50			
	$I_C = 10$ mA, $V_{CE} = 10V$	50			
	$I_C = 150$ mA, $V_{CE} = 10V$	50	150	400	
	$I_C = 500$ mA, $V_{CE} = 10V$	30			
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA $I_C = 500$ mA, $I_B = 50$ mA			0.5 1.2	V V
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA $I_C = 500$ mA, $I_B = 50$ mA			1.3 1.6	V V
BV_{CEO}	$I_C = 10$ mA	35			V
BV_{CBO}	$I_C = 100\ \mu A$	50			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 35V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA

Process 63

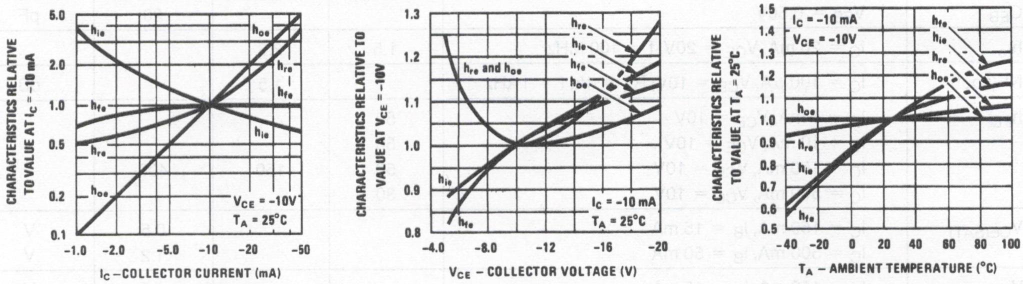
ELECTRICAL CHARACTERISTICS (T_A = 25°C) (Continued)

Symbol	Conditions	Min	Typ	Max	Units
$P_{D(max)}$					
TO-5	T_C = 25°C	3			W
	T_A = 25°C	800			mW
TO-18	T_C = 25°C	1.7			W
	T_A = 25°C	600			mW
TO-237	T_C = 25°C	2			W
	T_A = 25°C	850			mW
TO-116	T_A = 25°C				
	(Each Transistor)	500			mW
	(Total Dissipation)	900			mW
TO-236	T_C = 25°C	350			mW
$T_{J(max)}$	All Metal Can Parts	200			°C
	All Plastic Parts	150			°C

SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

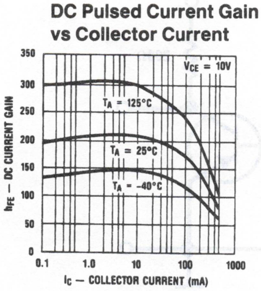
Symbol	Parameter	Conditions	Min	Typ	Max	Units
h_{ie}	Input Resistance	I_C = 10 mA, V_{CE} = −10V		480	2000	Ω
h_{oe}	Output Conductance	I_C = 10 mA, V_{CE} = −10V		80	1200	μmhos
h_{re}	Voltage Feedback Ratio	I_C = 10 mA, V_{CE} = −10V		162	1500	$\times 10^{-6}$
h_{fe}	Small Signal Current Gain	I_C = 10 mA, V_{CE} = −10V	100			

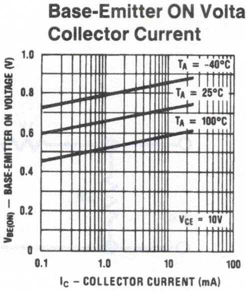
TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

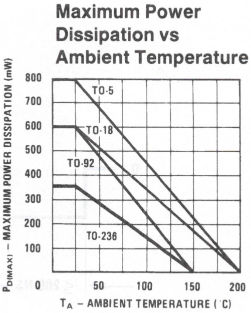


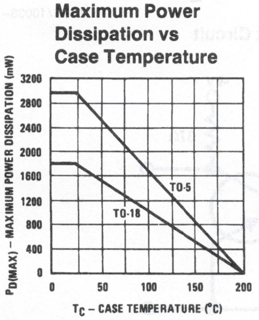
TL/G/10038–13

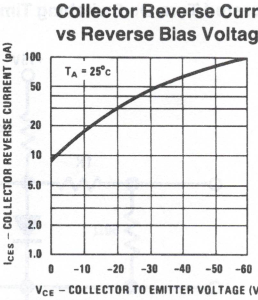
Process 63

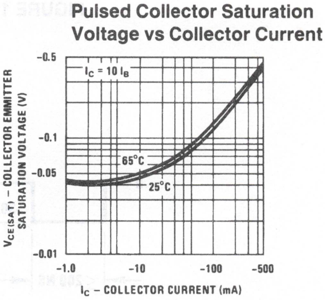

DC Pulsed Current Gain vs Collector Current


Base-Emitter ON Voltage vs Collector Current

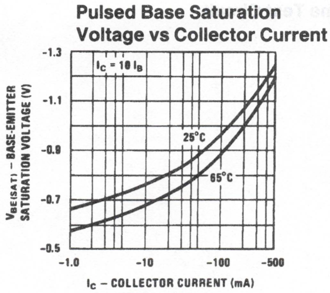

Maximum Power Dissipation vs Ambient Temperature

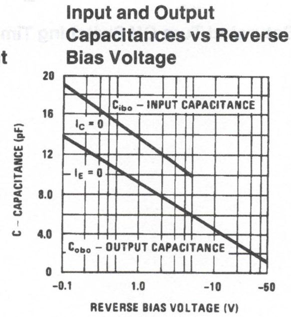

Maximum Power Dissipation vs Case Temperature

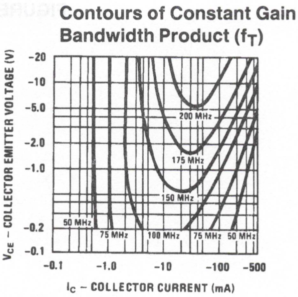

Collector Reverse Current vs Reverse Bias Voltage

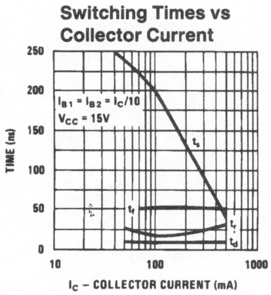

Pulsed Collector Saturation Voltage vs Collector Current

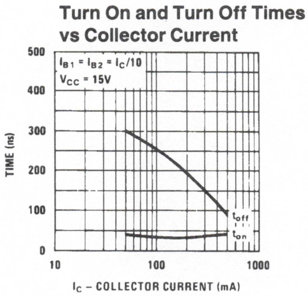
TL/G/10038–9

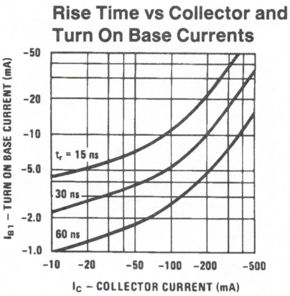

Pulsed Base Saturation Voltage vs Collector Current


Input and Output Capacitances vs Reverse Bias Voltage


Contours of Constant Gain Bandwidth Product (f_T)

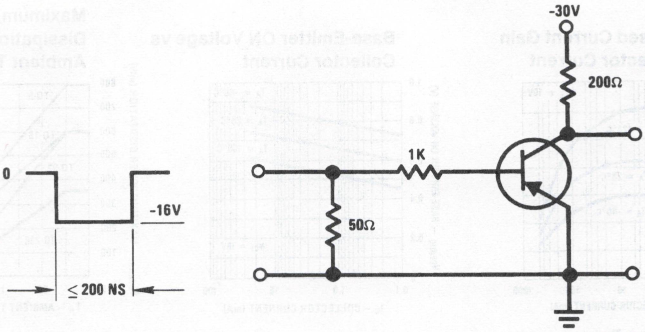

Switching Times vs Collector Current


Turn On and Turn Off Times vs Collector Current


Rise Time vs Collector and Turn On Base Currents

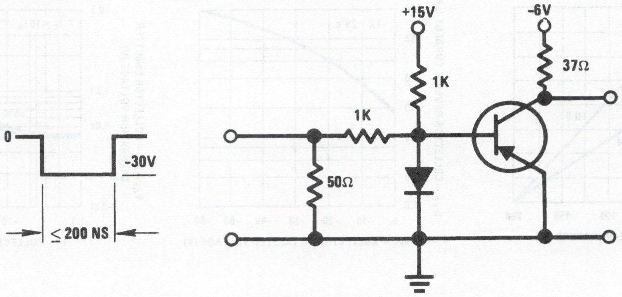
TL/G/10038–10

Process 63


-30V
200Ω
1K
50Ω
0
-16V
≤ 200 NS

TL/G/10038-11

FIGURE 1. Saturated Turn On Switching Time Test Circuit

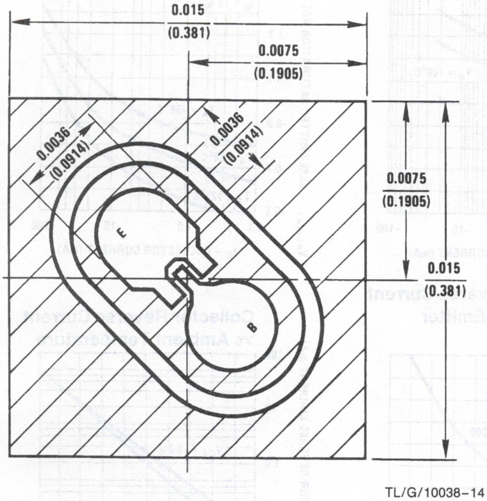

+15V
-6V
37Ω
1K
1K
50Ω
0
-30V
≤ 200 NS

TL/G/10038-12

FIGURE 2. Saturated Turn Off Switching Time Test Circuit

National Semiconductor

Process 65
PNP High Speed Switch



TL/G/10038-14

DESCRIPTION

Process 65 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 21.

APPLICATION

This device was designed for very high speed saturate switching at collector currents to 50 mA.

PRINCIPAL DEVICE TYPES

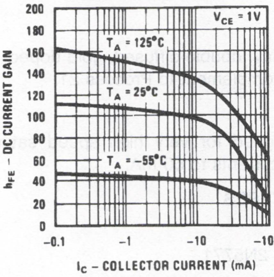
TO-18 EBC:	2N4208
TO-92 EBC:	PN3640, 2N5771
TO-236:	MMBT3640
TO-116:	MPQ3640
16-SOIC:	MMPQ3640

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

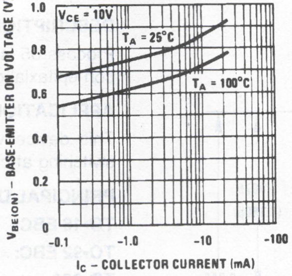
Symbol	Conditions	Min	Typ	Max	Units
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1$ mA *(Figure 1)*		18	25	ns
t_{ON}	$I_C = 10$ mA, $I_{B1} = 1$ mA *(Figure 1)*		11	15	ns
t_s	$I_C = I_{B1} = I_{B2} = 10$ mA		15	20	ns
C_{ob}	$V_{CB} = 5V$		2	3	pF
C_{ib}	$V_{EB} = 0.5V$			3.5	pF
h_{fe}	$V_{CE} = 10V$, $I_C = 10$ mA, f = 100 MHz	6.5	9		
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	20			
	$I_C = 10$ mA, $V_{CE} = 1V$	30	85	150	
	$I_C = 50$ mA, $V_{CE} = 1V$	25	75		
	$I_C = 100$ mA, $V_{CE} = 1V$	20			
	$I_C = 1$ mA, $V_{CE} = 0.5V$	20			
	$I_C = 10$ mA, $V_{CE} = 0.3V$	20			
$V_{CE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.15	V
	$I_C = 10$ mA, $I_B = 1$ mA			0.20	V
	$I_C = 50$ mA, $I_B = 5$ mA			0.50	V
$V_{BE(SAT)}$	$I_C = 1$ mA, $I_B = 0.1$ mA			0.8	V
	$I_C = 10$ mA, $I_B = 1$ mA			0.95	V
	$I_C = 50$ mA, $I_B = 5$ mA			1.5	V
BV_{CEO}	$I_C = 3$ mA	15			V
BV_{CBO}	$I_C = 100\ \mu A$	15			V
BV_{EBO}	$I_C = 10\ \mu A$	4.5			V
I_{CBO}	$V_{CB} = 10V$			100	nA
I_{EBO}	$V_{EB} = 3V$			100	nA

Process 65

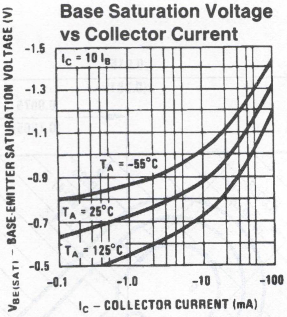
DC Current Gain vs Collector Current



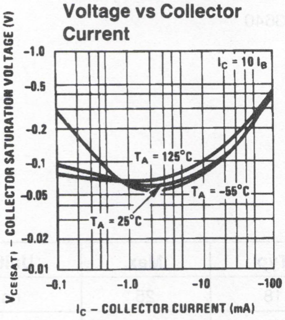
Base-Emitter ON Voltage vs Collector Current



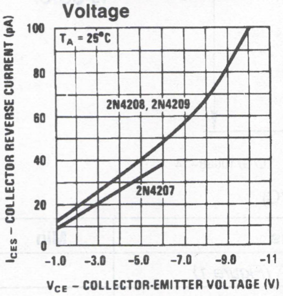
Base Saturation Voltage vs Collector Current



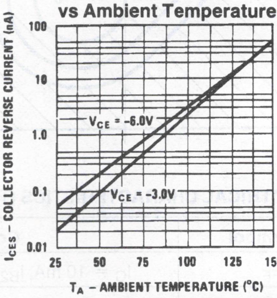
Collector Saturation Voltage vs Collector Current



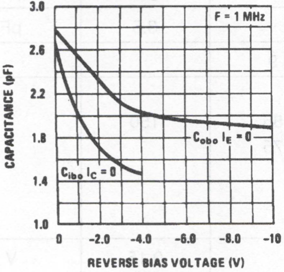
Collector Reverse Current vs Collector-Emitter Voltage



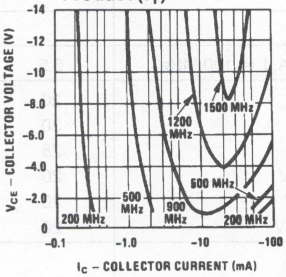
Collector Reverse Current vs Ambient Temperature



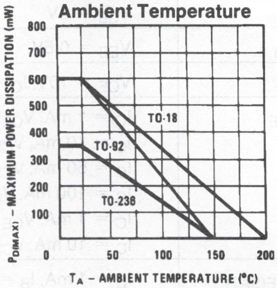
Input and Output Capacitance vs Reverse Bias Voltage



Contours of Constant Gain Bandwidth Product (f_T)



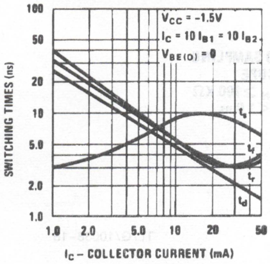
Maximum Power Dissipation vs Ambient Temperature



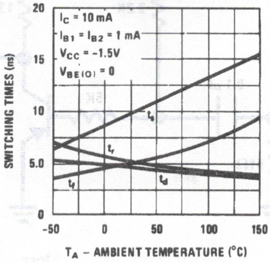
TL/G/10038–15

Process 65

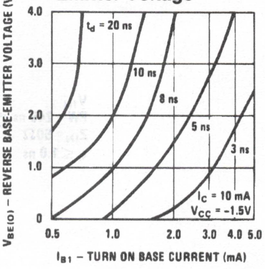
Switching Times vs Collector Current



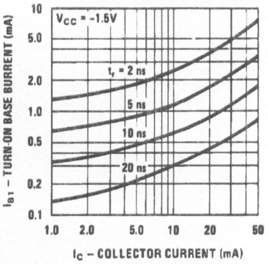
Switching Times vs Ambient Temperature



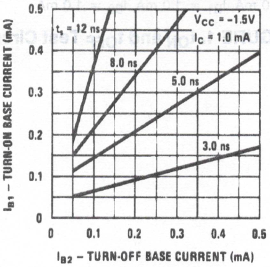
Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage



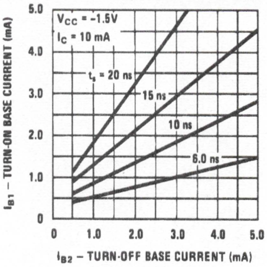
Rise Time vs Collector and Turn On Base Currents



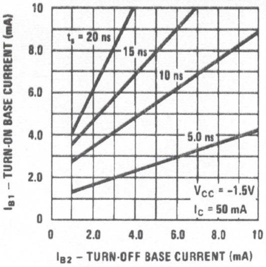
Storage Time vs Turn On and Turn Off Base Currents



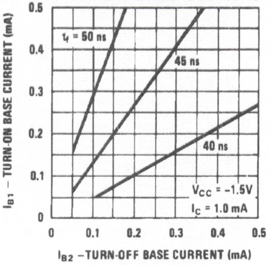
Storage Time vs Turn On and Turn Off Base Currents



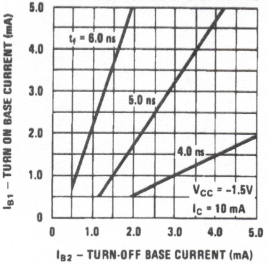
Storage Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents

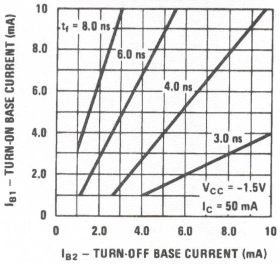


Fall Time vs Turn On and Turn Off Base Currents



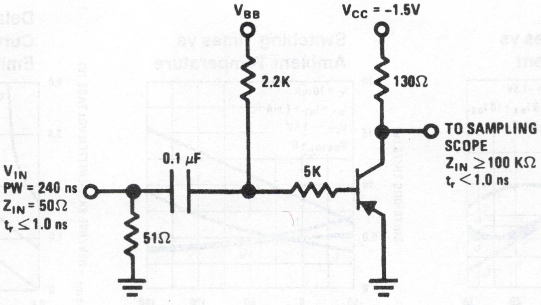
TL/G/10038–16

Fall Time vs Turn On and Turn Off Base Currents



TL/G/10038–17

Process 65


V_BB
V_CC = −1.5V
2.2K
130Ω
TO SAMPLING SCOPE
Z_IN ≥ 100 KΩ
t_r < 1.0 ns
0.1 μF
5K
V_IN
PW = 240 ns
Z_IN = 50Ω
t_r ≤ 1.0 ns
51Ω

TL/G/10038-18

t_{ON}
V_{BB} = Ground
$V_{IN} = -5.8V$

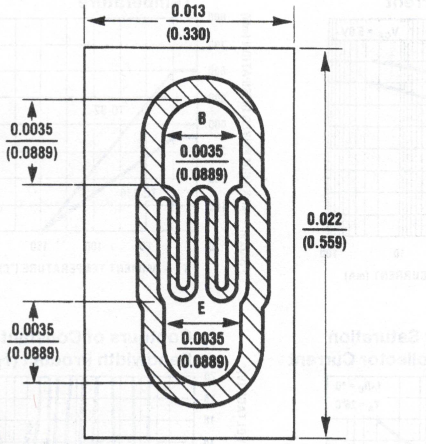
t_{OFF}
$V_{BB} = -8.0V$
$V_{IN} = +9.8V$

$I_C = 10$ mA, $I_{B1} = 1.0$ mA, $I_{B2} = 1.0$ mA

FIGURE 1. t_{ON} and t_{OFF} Test Circuit

National Semiconductor

Process 66
PNP Small Signal



TL/G/10038–19

DESCRIPTION

Process 66 is an overlay, double-diffused, silicon epitaxial device. Complement to Process 23.

APPLICATION

This device was designed for general purpose amplifier and switching applications at collector currents of 10 μA to 100 mA.

PRINCIPAL DEVICE TYPES

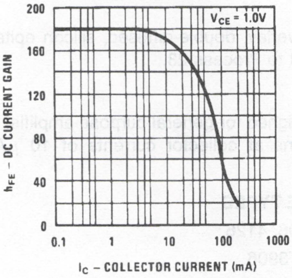
TO-92 EBC:	2N3906, 4126
TO-236:	MMBT3906
TO-116:	MPQ3906
16-SOIC:	MMPQ3906

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

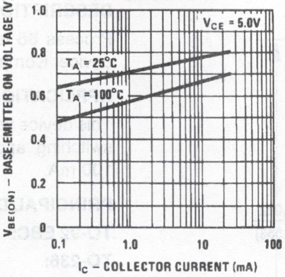
Symbol	Conditions	Min	Typ	Max	Units
t_{OFF}	$I_C = 10$ mA, $I_{B2} = 1$ mA		150	300	ns
t_{ON}	$I_C = 10$ mA, $I_{B1} = 1$ mA		30	70	ns
C_{ob}	$V_{CB} = 5V$		3.0	4.5	pF
C_{ib}	$V_{EB} = 0.5V$			15	pF
h_{fe}	f = 100 MHz, $V_{CE} = 20V$, $I_C = 10$ mA	2.5	4.5		
NF (wideband)	$I_C = 100\ \mu A$, $V_{CE} = 5V$, $R_S = 1\ k\Omega$		2.0		dB
h_{FE}	$I_C = 0.1$ mA, $V_{CE} = 1V$	40			
	$I_C = 1$ mA, $V_{CE} = 1V$	50			
	$I_C = 10$ mA, $V_{CE} = 1V$	50	150	350	
	$I_C = 50$ mA, $V_{CE} = 1V$	40			
	$I_C = 100$ mA, $V_{CE} = 1V$	20			
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.25	V
	$I_C = 50$ mA, $I_B = 5$ mA			0.40	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA			0.85	V
	$I_C = 50$ mA, $I_B = 5$ mA			0.95	V
BV_{CEO}	$I_C = 1$ mA	35			V
BV_{CBO}	$I_C = 10\ \mu A$	45			V
BV_{EBO}	$I_C = 10\ \mu A$	5.0			V
I_{CBO}	$V_{CB} = 25V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA

Process 66

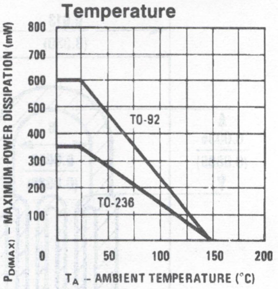
DC Current Gain vs Collector Current



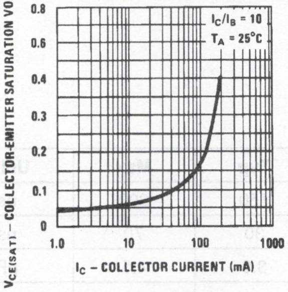
Base-Emitter ON Voltage vs Collector Current



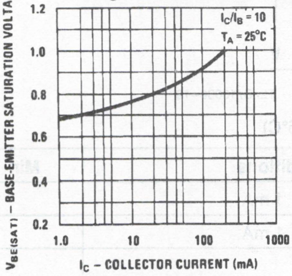
Maximum Power Dissipation vs Ambient Temperature



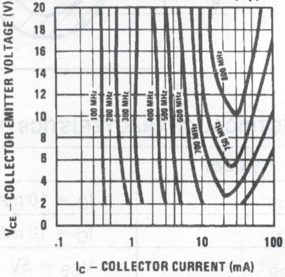
Collector-Emitter Saturation Voltage vs Collector Current



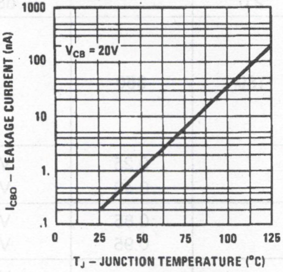
Base-Emitter Saturation Voltage vs Collector Current



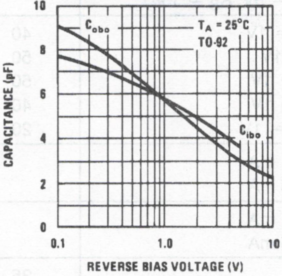
Contours of Constant Gain Bandwidth Product (f_T)



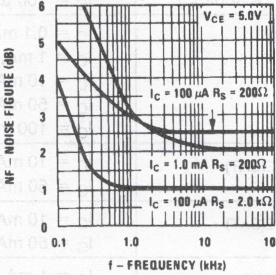
Collector-Base Diode Reverse Current vs Temperature



Common Base Open Circuit Input and Output Capacitance vs Reverse Bias Voltage



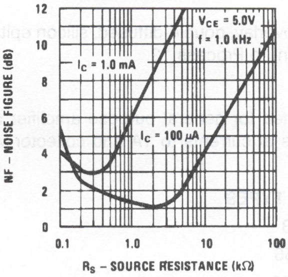
Noise Figure vs Frequency



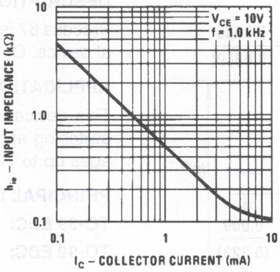
TL/G/10038–21

Process 66

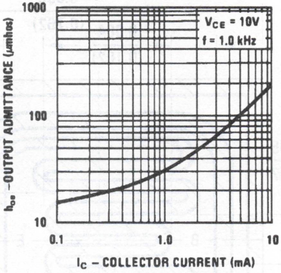
Noise Figure vs Source Resistance



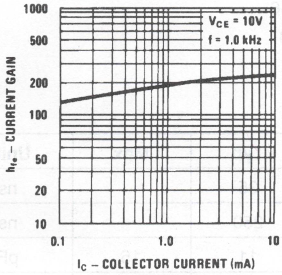
Input Impedance



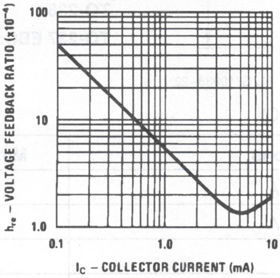
Output Admittance



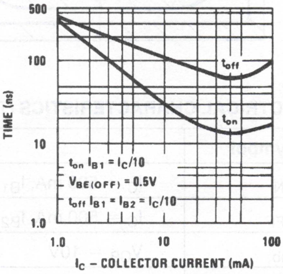
Current Gain



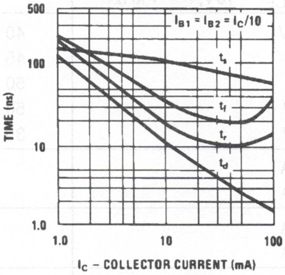
Voltage Feedback Ratio



Turn On and Turn Off Times vs Collector Current



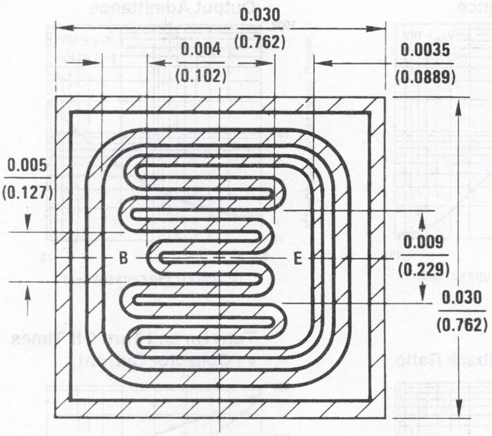
Switching Times vs Collector Current



TL/G/10038-20

National Semiconductor

Process 67
PNP Medium Power



TL/G/10038-22

DESCRIPTION

Process 67 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 12.

APPLICATION

This device is designed for general purpose amplifier and switching applications at currents to 1A and collector voltages up to 70V.

PRINCIPAL DEVICE TYPES

TO-39 EBC:	2N4033
TO-92 EBC:	MPSA56
TO-116:	MPQA56
TO-202 EBC:	NSDU56
TO-226 EBC:	MPSW56
TO-236:	MMBT56
TO-237 EBC:	TN4033

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

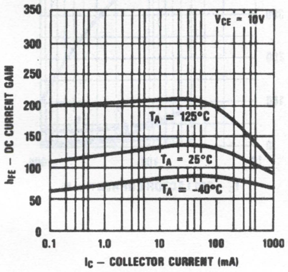
Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	$I_C = 500$ mA, $I_{B1} = 50$ mA		35		ns
t_{OFF}	$I_C = 500$ mA, $I_{B2} = 50$ mA		250		ns
C_{ob}	$V_{CB} = 10V$		11	15	pF
C_{ib}	$V_{EB} = 0.50V$			90	pF
h_{fe}	$V_{CE} = 10V$, $I_C = 50$ mA, f = 100 MHz	1	2		
NF (spot)	$I_C = 100\ \mu A$, $R_S = 1k$, $V_{CE} = 10V$, f = 1 kHz		1		dB
h_{FE}	$I_C = 0.10$ mA, $V_{CE} = 10V$	40			
	$I_C = 1.0$ mA, $V_{CE} = 10V$	45			
	$I_C = 10$ mA, $V_{CE} = 10V$	50			
	$I_C = 100$ mA, $V_{CE} = 10V$	50	150	350	
	$I_C = 500$ mA, $V_{CE} = 10V$	35			
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.2	V
	$I_C = 500$ mA, $I_B = 50$ mA			0.6	
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			1.0	V
	$I_C = 500$ mA, $I_B = 50$ mA			1.2	
BV_{CEO}	$I_C = 10$ mA	60			V
BV_{CBO}	$I_C = 100\ \mu A$	70			V
BV_{EBO}	$I_E = 10\ \mu A$	7			V
I_{CBO}	$V_{CB} = 50V$			100	nA
I_{EBO}	$V_{EB} = 5V$			100	nA

Process 67

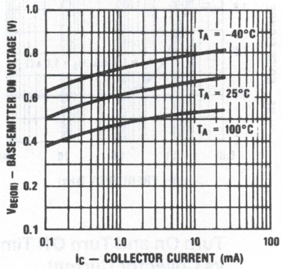
ELECTRICAL CHARACTERISTICS (T_A = 25°C) (Continued)

Symbol	Conditions	Min	Typ	Max	Units
$P_{D(max)}$					
TO-202	T_C = 25°C	10			W
	T_A = 25°C	2			W
TO-237	T_C = 25°C	2			W
	T_A = 25°C	850			mW
TO-226	T_A = 25°C	1			W
TO-92	T_A = 25°C	600			mW
TO-39	T_C = 25°C	7			W
	T_A = 25°C	1			W
TO-236	T_C = 25°C	350			mW
TO-116	T_A = 25°C				
	(Each Device)	500			mW
	(Total Dissipation)	900			mW

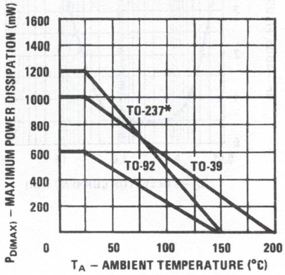
DC Pulsed Current Gain vs Collector Current



Base-Emitter ON Voltage vs Collector Current



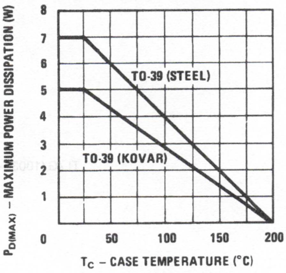
Maximum Power Dissipation vs Ambient Temperature



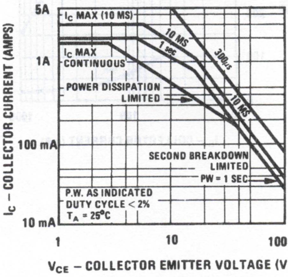
TL/G/10038–23

*One square inch of copper run

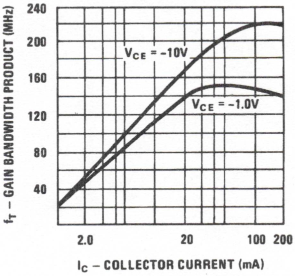
Maximum Power Dissipation vs Case Temperature



Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink

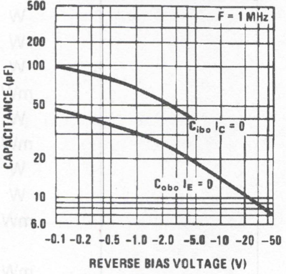


Gain Bandwidth Product vs Collector Current

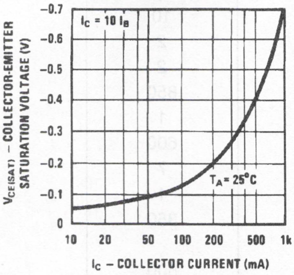


TL/G/10038–24

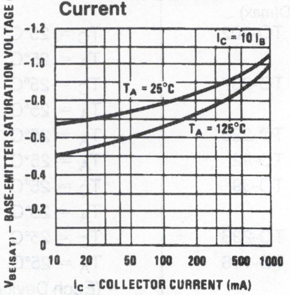
Process 67



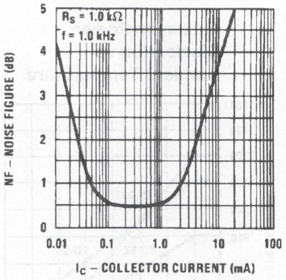
Common Base Open Circuit Input and Output Capacitance vs Reverse Bias Voltage



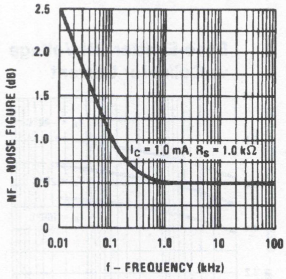
Collector-Emitter Saturation Voltage vs Collector Current



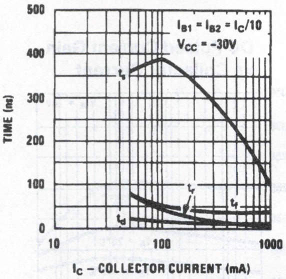
Base-Emitter Saturation Voltage vs Collector Current



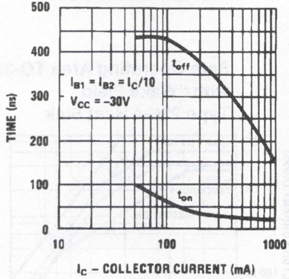
Noise Figure vs Collector Current



Noise Figure vs Frequency



Switching Times vs Collector Current

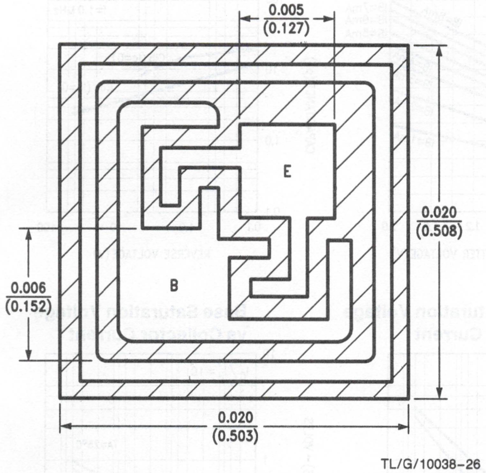


Turn On and Turn Off Times vs Collector Current

TL/G/10038-25

National Semiconductor

Process 68
PNP Small Signal



TL/G/10038-26

GENERAL DESCRIPTION

Process 68 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 10.

APPLICATION

This device was designed for general purpose amplifier applications at collector currents to 500 mA.

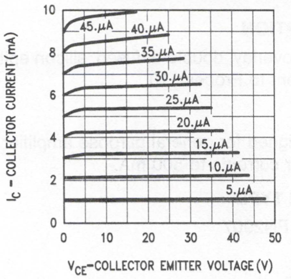
PRINCIPAL DEVICE TYPE

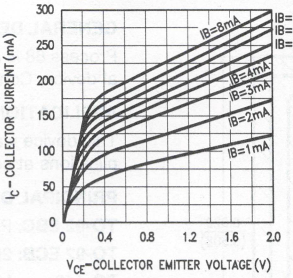
TO-92 EBC:	PN200, PN2907
TO-92 ECB:	2N4061
TO-116:	MPQ200
TO-236:	MMBT200, 200A
16-SOIC:	MMPQ200

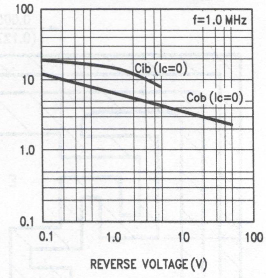
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

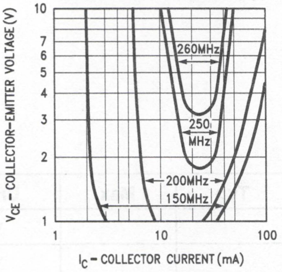
Symbol	Conditions	Min	Typ	Max	Units
BV_{CBO}	$I_C = 10\ \mu A$	60			V
BV_{CEO}	$I_C = 1\ mA$	45			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 50V$			50	nA
I_{CES}	$V_{CE} = 40V$			50	nA
I_{EBO}	$V_{EB} = 4V$			50	nA
h_{FE}	$I_C = 100\ \mu A, V_{CE} = 1V$	80			
	$I_C = 10\ mA, V_{CE} = 1V$	100	250	600	
	$I_C = 100\ mA, V_{CE} = 1V$	100			
	$I_C = 150\ mA, V_{CE} = 5V$	100		500	
	$I_C = 300\ mA, V_{CE} = 5V$	50			
$V_{CE(s)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.2	V
$V_{BE(s)}$	$I_C = 10\ mA, I_B = 1\ mA$			0.85	V
$V_{CE(s)}$	$I_C = 200\ mA, I_B = 20\ mA$			0.4	V
$V_{BE(s)}$	$I_C = 200\ mA, I_B = 20\ mA$			1.0	V
C_{ob}	$V_{CB} = 5V, f = 1\ MHz$		4.0	6.0	pF
f_T	$V_{CE} = 20V, I_C = 20\ mA$	200	300		MHz
t_s	$I_C = 10\ mA, I_{B_1} = I_{B_2} = 1\ mA$		275		ns
t_{OFF}	$I_C = 150\ mA, I_{B_1} = I_{B_2} = 15\ mA$		225		ns
NF	$I_C = 100\ \mu A, V_{CE} = 5V, R_G = 2\ k\Omega, f = 1\ kHz$		1.5		dB
$P_{D(max)}$					
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW

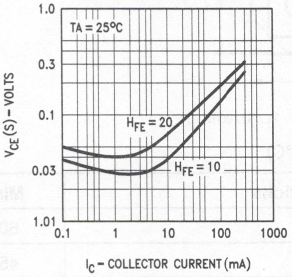
Process 68

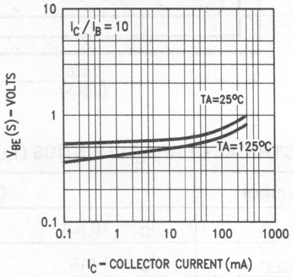

Collector Current vs Collector-Emitter Voltage

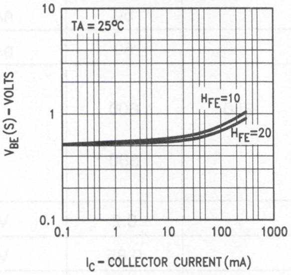

Collector Current vs Collector-Emitter Voltage

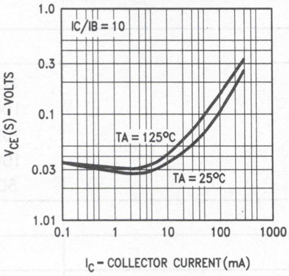

Input and Output Capacitance vs Reverse Voltage

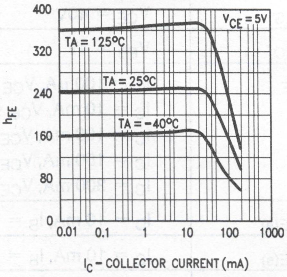

Contours of Constant Gain Bandwidth Product (fT)

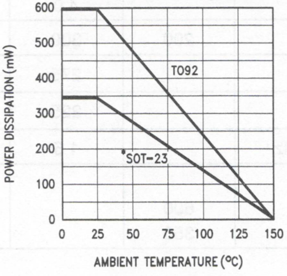

Collector Saturation Voltage vs Collector Current

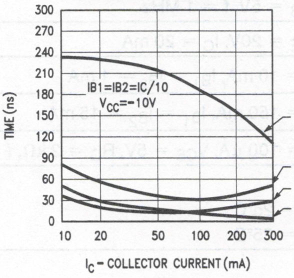

Base Saturation Voltage vs Collector Current


Base Saturation Voltage vs Collector Current


Collector Saturation Voltage vs Collector Current


DC Current Gain vs Collector Current


Total Power Dissipation vs Ambient Temperature

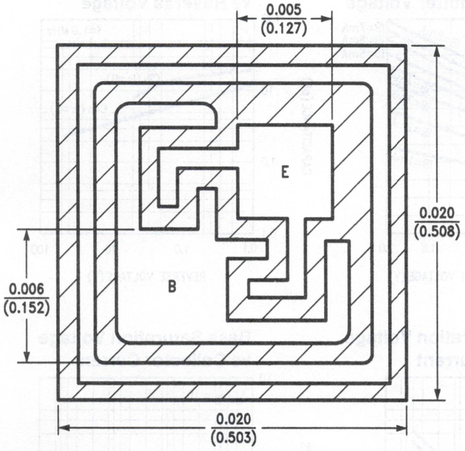

Switching Times vs Collector Current

*Mounted on 10 x 8 x 0.6 mm copper pad on epoxy-glass FR-4 board.

TL/G/10038-27

National Semiconductor

Process 69
PNP Small Signal



TL/G/10038-26

DESCRIPTION

Process 69 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 11.

APPLICATION

These devices are designed for general purpose amplifier applications to 300 mA collector current.

PRINCIPAL DEVICE TYPES

TO-92 EBC: PN201

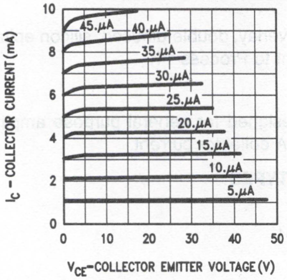
TO-236: MMBT201

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

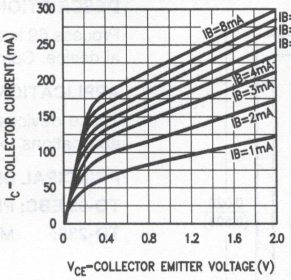
Symbol	Conditions	Min	Typ	Max	Units
C_{ob}	V_{CB} = 10V, f = 1 MHz		3.0	4.0	pF
C_{ib}	V_{EB} = 0.5V, f = 1 MHz		16	25	pF
NF	I_C = 100 μA, V_{CE} = 5V R_S = 2 kΩ, f = 1 KHz		2.0		dB
f_T	V_{CE} = 10V, I_C = 20 mA	150	250		MHz
h_{FE}	V_{CE} = 1.0V, I_C = 1 mA	40			
	V_{CE} = 1.0V, I_C = 100 mA	100	200	400	
	V_{CE} = 1.0V, I_C = 150 mA	75			
$V_{CE(SAT)}$	I_C = 150 mA, I_B = 15 mA			0.5	V
$V_{BE(SAT)}$	I_C = 150 mA, I_B = 15 mA			1.0	V
BV_{CBO}	I_C = 10 μA	80			
BV_{CEO}	I_C = 1 mA	65			
BV_{EBO}	I_E = 10 μA	6.0			
I_{CBO}	V_{CB} = 40V			50	nA
I_{CES}	V_{CE} = 30V			50	nA
I_{EBO}	V_{EB} = 4.0V			50	nA
$P_{D(max)}$					
TO-92	T_A = 25°C	600			mW
TO-236	T_C = 25°C	350			mW

Process 69

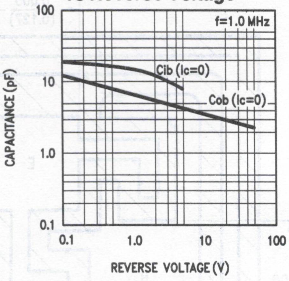
Collector Current vs Collector-Emitter Voltage



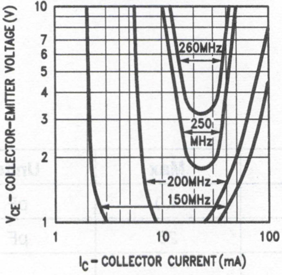
Collector Current vs Collector-Emitter Voltage



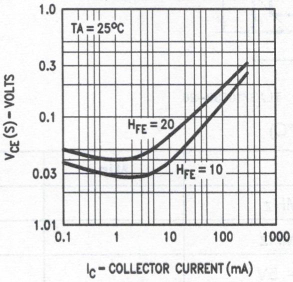
Input and Output Capacitance vs Reverse Voltage



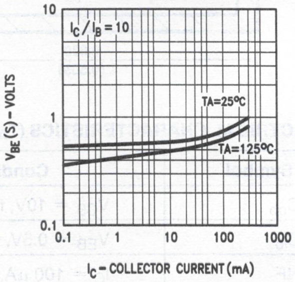
Contours of Constant Gain Bandwidth Product (f_T)



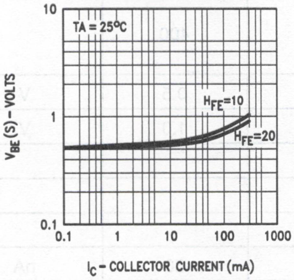
Collector Saturation Voltage vs Collector Current



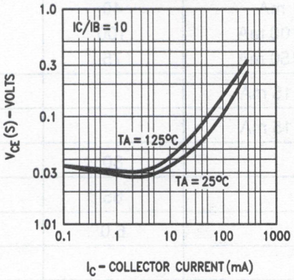
Base Saturation Voltage vs Collector Current



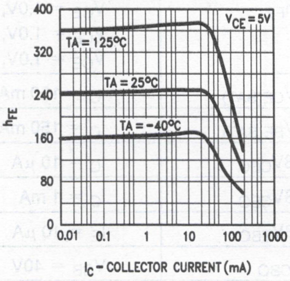
Base Saturation Voltage vs Collector Current



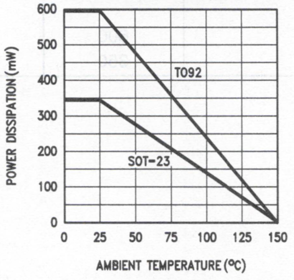
Collector Saturation Voltage vs Collector Current



DC Current Gain vs Collector Current



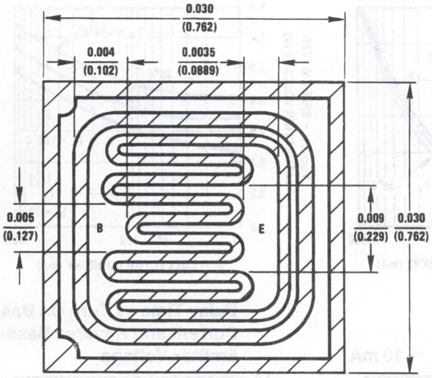
Total Power Dissipation vs Ambient Temperature



TL/G/10038-29

National Semiconductor

Process 70
PNP Memory Driver



TL/G/10038-35

DESCRIPTION

Process 70 is a non-overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 25.

APPLICATION

This device was designed primarily for high speed saturated switching applications to currents of 1A.

PRINCIPAL DEVICE TYPES

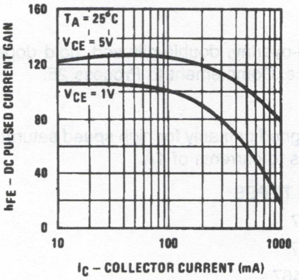
TO-39 EBC:	2N3467
TO-237 EBC:	TN3467
TO-116:	MPQ3467

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

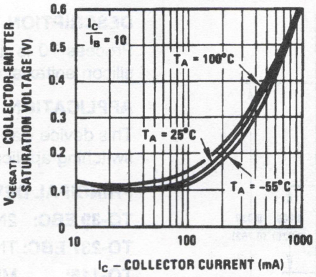
Symbol	Conditions	Min	Typ	Max	Units
t_{ON}	$I_C = 500$ mA, $I_{B1} = 50$ mA *(Figure 1)*		20	40	ns
t_{OFF}	$I_C = 500$ mA, $I_{B2} = 50$ mA *(Figure 2)*		60	90	ns
C_{ob}	$V_{CB} = -10V$		15	20	pF
C_{ib}	$V_{EB} = -0.5V$			80	pF
h_{FE}	$I_C = 100$ mA, $V_{CE} = -1V$	40	100	200	
	$I_C = 500$ mA, $V_{CE} = -1V$	30		120	
	$I_C = 1A$, $V_{CE} = -1V$	15			
$V_{CE(SAT)}$	$I_C = 150$ mA, $I_B = 15$ mA			0.3	V
	$I_C = 500$ mA, $I_B = 50$ mA			0.6	V
	$I_C = 1A$, $I_B = 100$ mA			1.0	V
$V_{BE(SAT)}$	$I_C = 150$ mA, $I_B = 50$ mA			1.2	V
	$I_C = 500$ mA, $I_B = 50$ mA			1.2	V
	$I_C = 1A$, $I_B = 100$ mA			1.7	V
BV_{CEO}	$I_C = 10$ mA	40			V
BV_{CBO}	$I_C = 100\ \mu A$	50			V
BV_{EBO}	$I_E = 10\ \mu A$	6			V
I_{CBO}	$V_{CB} = 30V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
$P_{D(max)}$					
TO-39	$T_C = 25°C$	7			W
	$T_A = 25°C$	1			W
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-116	$T_A = 25°C$				
	(Total Dissipation)	1			W
	(Each Transistor)	600			mW
$T_{J(max)}$	All Metal Can Parts	200			°C
	All Plastic Parts	150			°C

Process 70

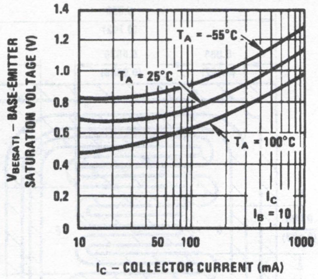
DC Pulsed Current Gain vs Collector Current



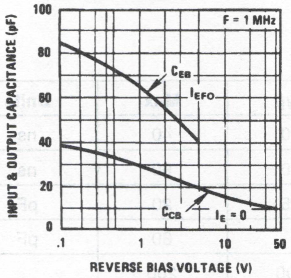
Collector-Emitter Saturation Voltage vs Collector Current



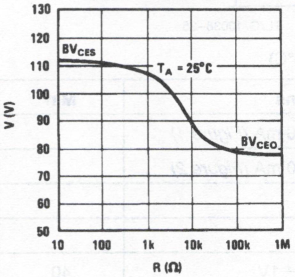
Base-Emitter Saturation Voltage vs Collector Current



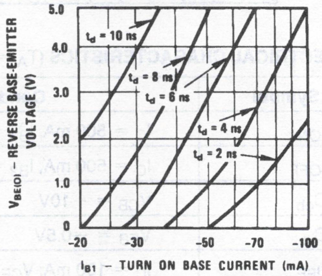
Input and Output Capacitance vs Reverse Bias Voltage



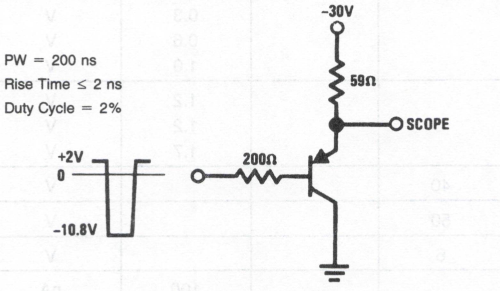
BV_{CER} vs R_{BE}, $I_C = 10$ mA



Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage

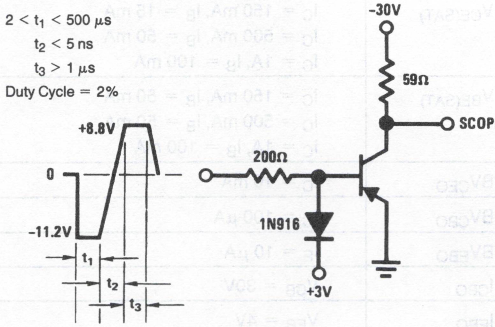


TL/G/10038-36


PW = 200 ns
Rise Time ≤ 2 ns
Duty Cycle = 2%
+2V
0
-10.8V
-30V
59Ω
SCOPE
200Ω

TL/G/10038-38

FIGURE 1. t_{ON} Equivalent Test Circuit

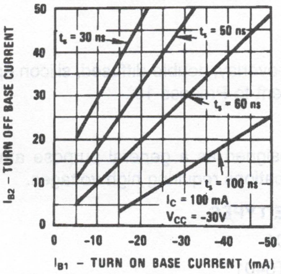

$2 < t_1 < 500$ μs
$t_2 < 5$ ns
$t_3 > 1$ μs
Duty Cycle = 2%
+8.8V
0
-11.2V
t_1
t_2
t_3
200Ω
1N916
+3V
-30V
59Ω
SCOPE

TL/G/10038-39

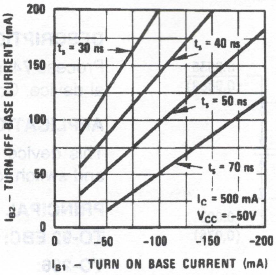
FIGURE 2. t_{OFF} Equivalent Test Circuit

Process 70

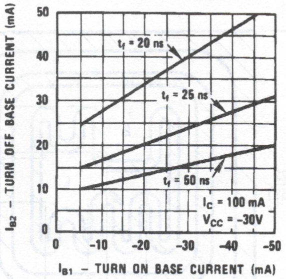
Storage Time vs Turn On and Turn Off Base Currents



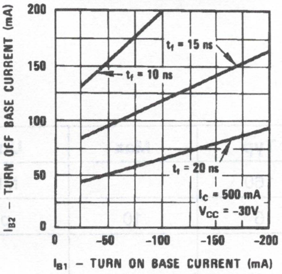
Storage Time vs Turn On and Turn Off Base Currents



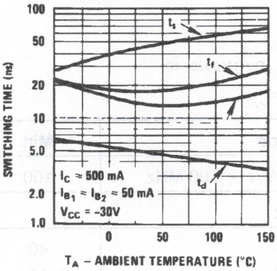
Fall Time vs Turn On and Turn Off Base Currents



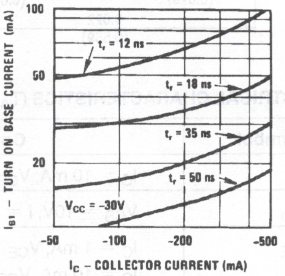
Fall Time vs Turn On and Turn Off Base Currents



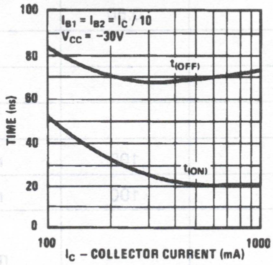
Switching Times vs Ambient Temperature



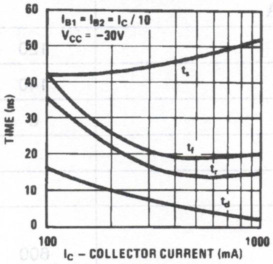
Rise Time vs Collector Current and Turn On Base Current



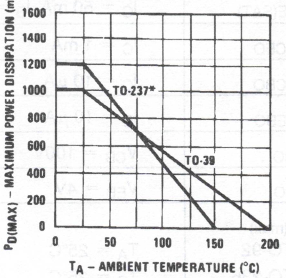
Turn On and Turn Off Times vs Collector Current



Switching Times vs Collector Current

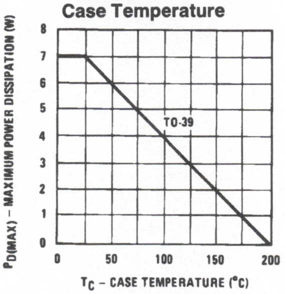


Maximum Power Dissipation vs Ambient Temperature



* One square inch of copper run

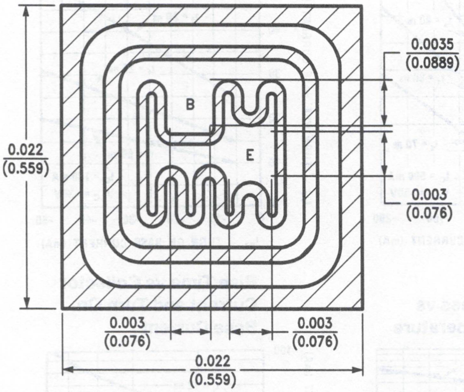
Maximum Power Dissipation vs Case Temperature



TL/G/10038–37

National Semiconductor

Process 74
PNP High Voltage



TL/G/10038-40

DESCRIPTION

Process 74 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 16.

APPLICATION

This device was designed as a general purpose amplifier and switch for applications requiring high voltages.

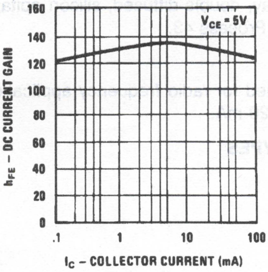
PRINCIPAL DEVICE TYPES

TO-92 EBC: 2N5401
TO-236: MMBT5401

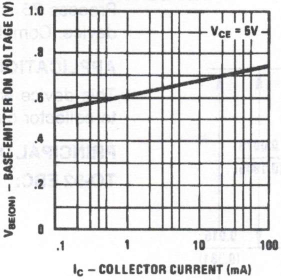
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
f_T	$I_C = 10$ mA, $V_{CE} = 10V$, f = 100 MHz	100	160		MHz
C_{ob}	$V_{CB} = 10V$, f = 1 MHz		6	10	pF
h_{FE}	$I_C = 1$ mA, $V_{CE} = 5V$	40			
	$I_C = 10$ mA, $V_{CE} = 5V$	50	120	250	
	$I_C = 50$ mA, $V_{CE} = 5V$	20			
$V_{BE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.95	V
$V_{CE(SAT)}$	$I_C = 50$ mA, $I_B = 5$ mA			0.50	V
BV_{CEO}	$I_C = 1$ mA	120			V
BV_{CBO}	$I_C = 10$ μA	140			V
BV_{EBO}	$I_E = 10$ μA	6			V
I_{CBO}	$V_{CB} = 100V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
$P_{D(max)}$					
TO-92	$T_A = 25°C$	600			mW
TO-236	$T_C = 25°C$	350			mW

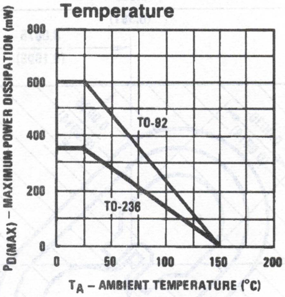
Process 74



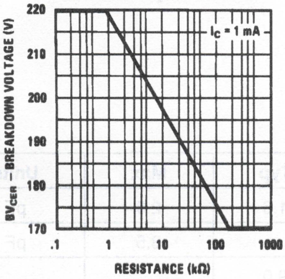
DC Current Gain vs Collector Current



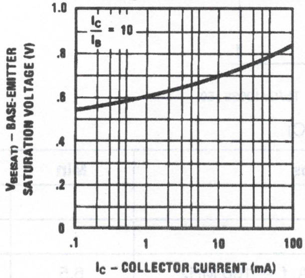
Base-Emitter ON Voltage vs Collector Current



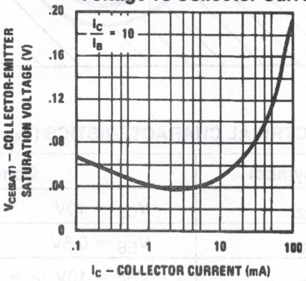
Maximum Power Dissipation vs Ambient Temperature



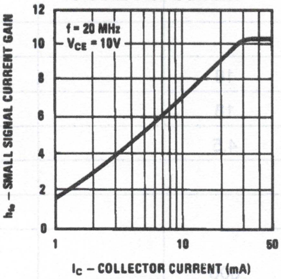
Collector-Emitter Breakdown Voltage with Resistance Between Base-Emitter



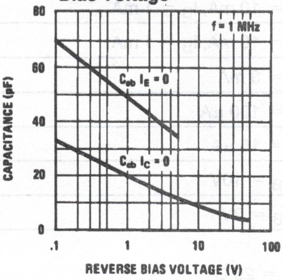
Base-Emitter Saturation Voltage vs Collector Current



Collector-Emitter Saturation Voltage vs Collector Current



Small Signal Current Gain vs Collector Current

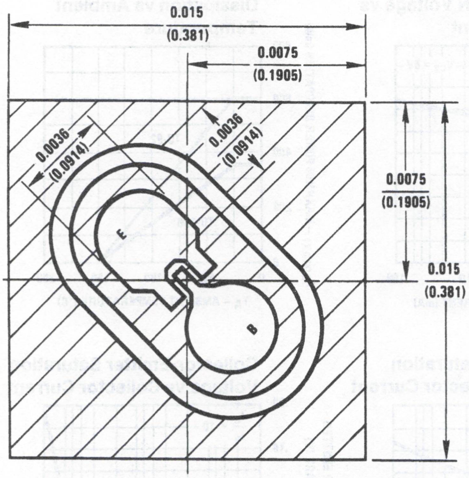


Input and Output Capacitance vs Reverse Bias Voltage

TL/G/10038–41

National Semiconductor

Process 75
PNP RF Amplifier



TL/G/10038-59

DESCRIPTION

Process 75 is an overlay, double-diffused, silicon epitaxial device. Complement to Process 43.

APPLICATION

This device was designed for radio frequency applications to collector currents to 20 mA.

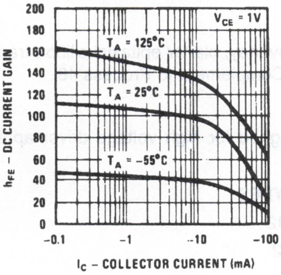
PRINCIPAL DEVICE TYPES

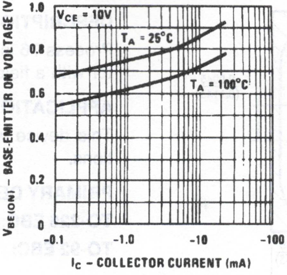
TO-92 EBC: PN5208

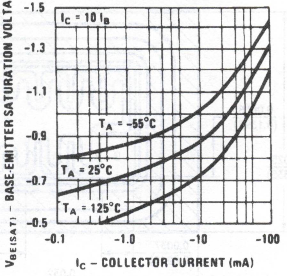
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

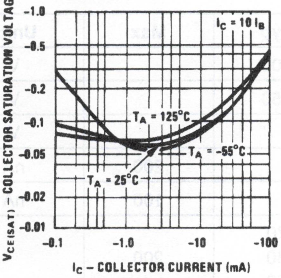
Symbol	Conditions	Min	Typ	Max	Units
C_{ob}	V_{CB} = 10V		1.6	2.0	pF
C_{ib}	V_{EB} = 0.5V			3.5	pF
h_{fe}	V_{CE} = 10V, I_C = 10 mA, f = 100 MHz	6.5	9.0		
h_{FE}	I_C = 5 mA, V_{CE} = 5V I_C = 10 mA, V_{CE} = 5V	30 40	 85	 180	
$V_{CE(SAT)}$	I_C = 10 mA, I_B = 1 mA			0.20	V
$V_{BE(SAT)}$	I_C = 10 mA, I_B = 1 mA			0.95	V
BV_{CEO}	I_C = 3 mA	18			V
BV_{CBO}	I_C = 100 μA	18			V
BV_{EBO}	I_C = 10 μA	4.5			V
I_{CBO}	V_{CB} = 10V			100	nA
I_{EBO}	V_{EB} = 3V			100	nA
$P_{D(max)}$ TO-92 TO-236	 T_A = 25°C T_C = 25°C	 600 350			 mW mW
$T_{J(max)}$	All Plastic Parts	150			°C

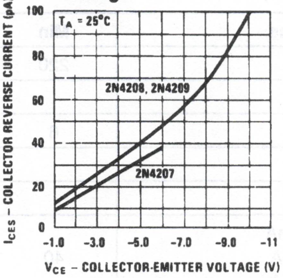
Process 75

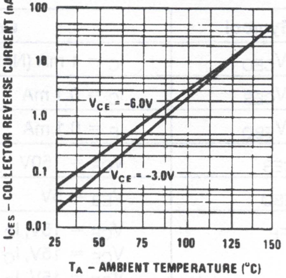

DC Current Gain vs Collector Current

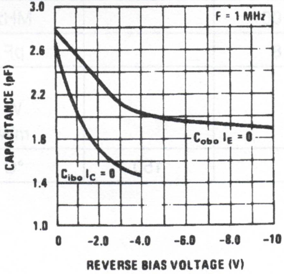

Base-Emitter ON Voltage vs Collector Current

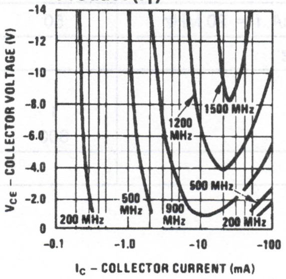

Base Saturation Voltage vs Collector Current

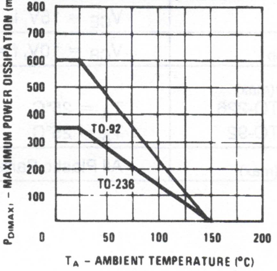

Collector Saturation Voltage vs Collector Current


Collector Reverse Current vs Collector-Emitter Voltage


Collector Reverse Current vs Ambient Temperature


Input and Output Capacitance vs Reverse Bias Voltage

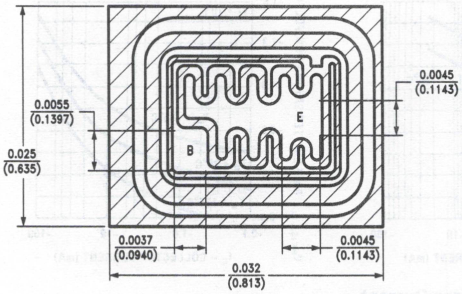

Contours of Constant Gain Bandwidth Product (f_T)


Maximum Power Dissipation vs Ambient Temperature

TL/G/10038-60

National Semiconductor

Process 76
PNP High Voltage Amplifier



TL/G/10038-42

DESCRIPTION

Process 76 is a non-overlay, planar epitaxial silicon transistor with a field plate. Complement to Process 48.

APPLICATION

This device was designed for high voltage driver applications.

PRIMARY DEVICE TYPES

TO-226 EBC: MPSW92

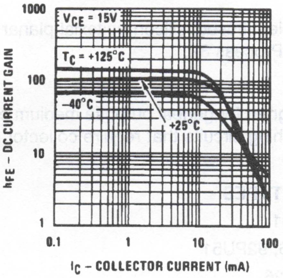
TO-92 EBC: MPSA92

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

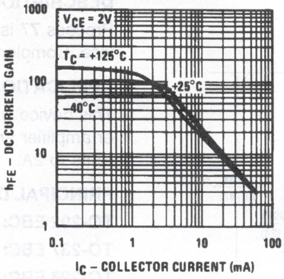
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 1$ mA (Note 1)	220	300		V
BV_{CES}	$I_C = 0.1$ mA		350		V
BV_{EBO}	$I_E = 0.1$ mA	6			V
I_{CES}	$V_{CE} = 150V$			200	nA
I_{EBO}	$V_{EB} = 5V$			100	nA
h_{FE}	$V_{CE} = 15V, I_C = 0.1$ mA $V_{CE} = 15V, I_C = 25$ mA $V_{CE} = 15V, I_C = 50$ mA	 40 	70 80 50	 200 	
$V_{CE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.3	1.0	V
$V_{BE(SAT)}$	$I_C = 10$ mA, $I_B = 1$ mA		0.8		V
f_T	$V_{CE} = 15V, I_C = 10$ mA, $f = 20$ MHz	50	100		MHz
C_{ob}	$V_{CB} = 10V, f = 1$ MHz		8		pF
$P_{D(max)}$ TO-226 TO-92	 $T_A = 25°C$ $T_A = 25°C$	 1 600			 W mW
$T_{J(max)}$	All Plastic Parts			150	°C

Process 76

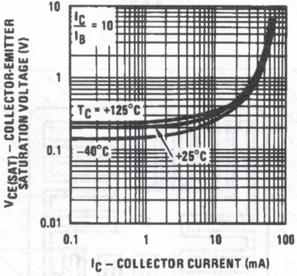
DC Current Gain vs Collector Current



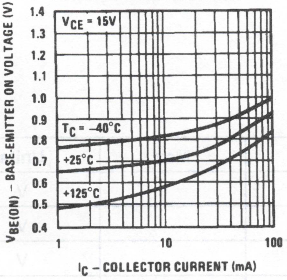
Pulsed Current Gain vs Collector Current



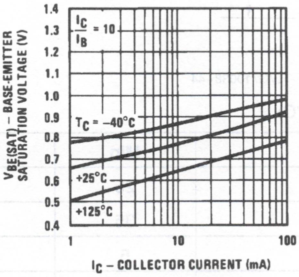
Collector-Emitter Saturation Voltage vs Collector Current



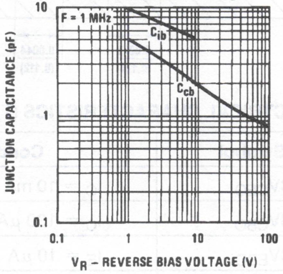
Base-Emitter ON Voltage vs Collector Current



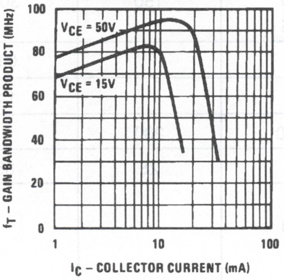
Base-Emitter Saturation Voltage vs Collector Current



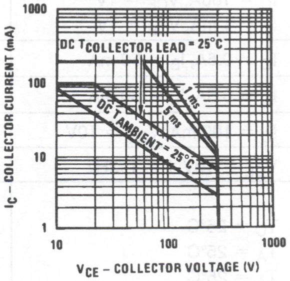
Junction Capacitance vs Reverse Bias Voltage



Gain Bandwidth Product vs Collector Current



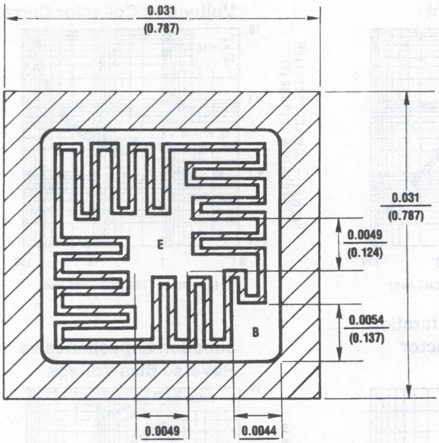
Safe Operating Area TO-226



TL/G/10038-43

National Semiconductor

Process 77
PNP Medium Power



TL/G/10038–44

DESCRIPTION

Process 77 is a double-diffused, silicon epitaxial planar device. Complement to Process 37.

APPLICATION

This device was designed for geneal purpose medium power amplifier and switching circuits that require collector currents to 2A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: NSDU51

TO-237 EBC: 2N6726, 92PU51

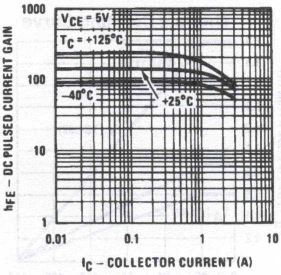
TO-226 EBC: MPS6726

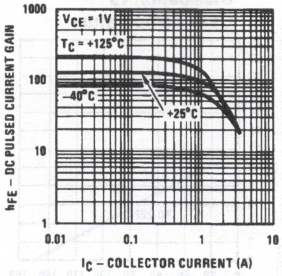
TO-92 EBC: PN6726

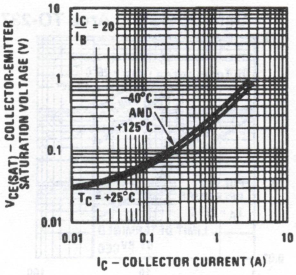
ELECTRICAL CHARACTERISTICS (T_A = 25°C)

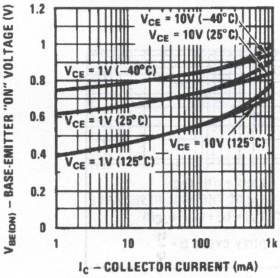
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	I_C = 10 mA	25			V
BV_{CBO}	I_C = 100 μA	35			V
BV_{EBO}	I_E = 10 μA	5			V
I_{CBO}	V_{CB} = 20V			100	nA
I_{EBO}	V_{EB} = 4V		10	100	nA
h_{FE}	I_C = 100A, V_{CE} = 1V	50	150	300	
	I_C = 1 mA, V_{CE} = 1V	35			
$V_{CE(SAT)}$	I_C = 0.5A, I_B = 50 mA			0.5	V
$V_{BE(SAT)}$	I_C = 0.5A, I_B = 50 mA			1.3	V
f_T	I_C = 100 mA, V_{CE} = 10V	100	200		MHz
C_{ob}	V_{CE} = 10V, f = 1 MHz		28	35	pF
$P_{D(max)}$					
TO-202	T_C = 25°C	10			W
	T_A = 25°C	2			W
TO-226	T_A = 25°C	1			W
TO-237	T_C = 25°C	2			W
	T_A = 25°C	850			mW
TO-92	T_A = 25°C	600			mW
θ_{JC}					
TO-202	T_C = 25°C			12.5	°C/W
TO-237	T_C = 25°C			62.5	°C/W
θ_{JA}					
TO-202	T_A = 25°C			62.5	°C/W
TO-226	T_A = 25°C			125	°C/W
TO-237	T_A = 25°C			147	°C/W
TO-92	T_A = 25°C			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

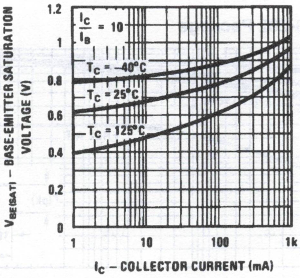
Process 77

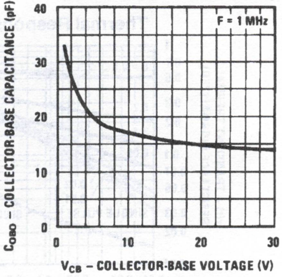

DC Pulsed Current Gain vs Collector Current

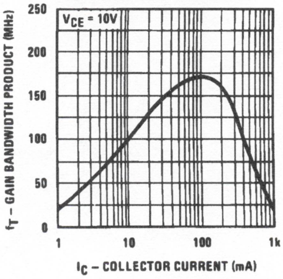

DC Pulsed Current Gain vs Collector Current

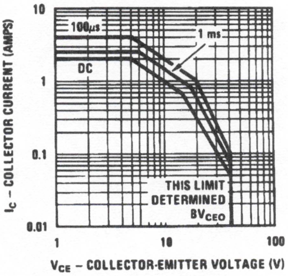

Collector-Emitter Saturation Voltage vs Collector Current


Base-Emitter ON Voltage vs Collector Current


Base-Emitter Saturation Voltage vs Collector Current


Collector-Base Capacitance vs Collector-Base Voltage

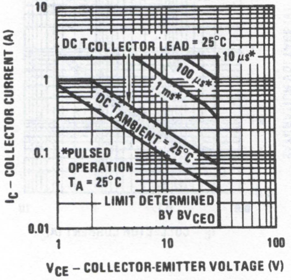

Gain Bandwidth Product vs Collector Current


Safe Operating Area TO-202

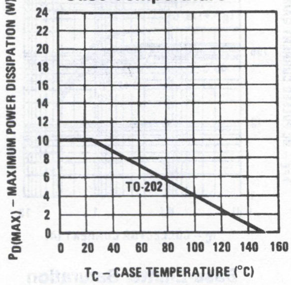
TL/G/10038–45

Process 77

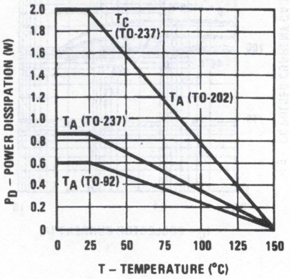
Safe Operating Area TO-237



Maximum Power Dissipation vs Case Temperature

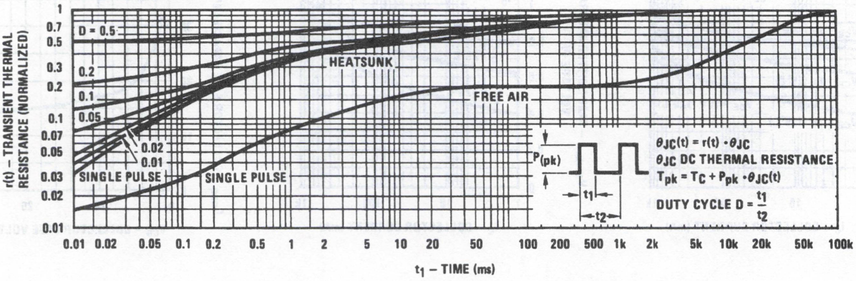


Thermal Derating Curve



TL/G/10038-46

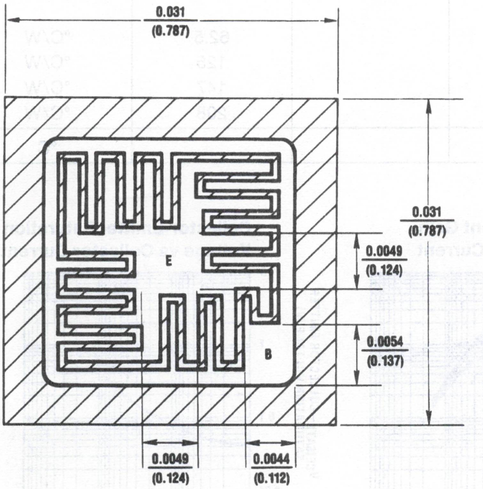
Thermal Response in TO-202 Package



TL/G/10038-48

National Semiconductor

Process 78
PNP Medium Power



TL/G/10038-49

DESCRIPTION

Process 78 is a double-diffused, silicon epitaxial planar device. Complement to Process 38.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1.5A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D4101-6, NSDU55
TO-237 EBC: 2N6727, 92PU55
TO-226 EBC: MPS6727
TO-92 EBC: PN6727

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

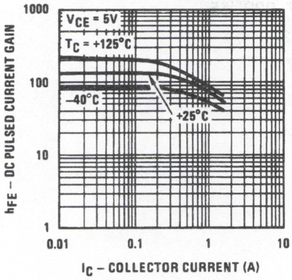
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	40			V
BV_{CBO}	$I_C = 100\ \mu A$	50			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 40V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	40			
	$I_C = 100$ mA, $V_{CE} = 1V$	50	150	300	
	$I_C = 500$ mA, $V_{CE} = 1V$	35			
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.6	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.3	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	80	150		MHz
C_{ob}	$V_{CB} = 10V$		20	25	pF
$P_{D(max)}$					
TO-202	$T_C = 25°C$	10			W
	$T_A = 25°C$	2			W
TO-226	$T_A = 25°C$	1			W
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_C = 25°C$			62.5	°C/W

Process 78

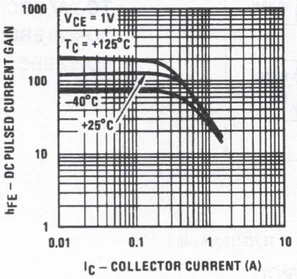
ELECTRICAL CHARACTERISTICS (T_A = 25°C (Continued)

Symbol	Conditions	Min	Typ	Max	Units
θ_{JA}					
TO-202	T_A = 25°C			62.5	°C/W
TO-226	T_A = 25°C			125	°C/W
TO-237	T_A = 25°C			147	°C/W
TO-92	T_A = 25°C			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

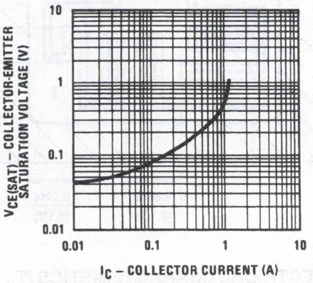
Pulsed Current Gain vs Collector Current



Pulsed Current Gain vs Collector Current

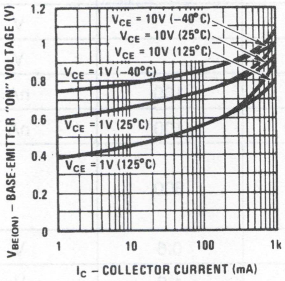


Collector-Emitter Saturation Voltage vs Collector Current

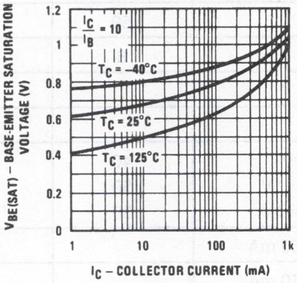


TL/G/10038–50

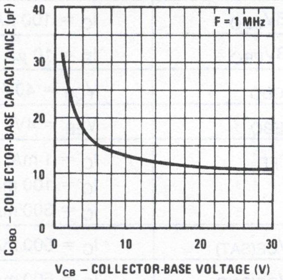
Base-Emitter ON Voltage vs Collector Current



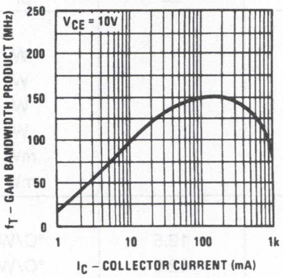
Base-Emitter Saturation Voltage vs Collector Current



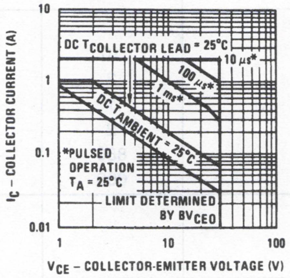
Collector-Base Capacitance vs Collector-Base Voltage



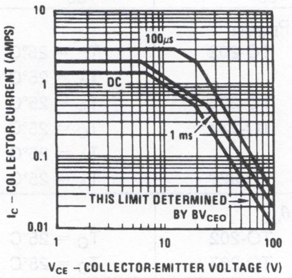
Gain Bandwidth Product vs Collector Current



Safe Operating Area TO-237



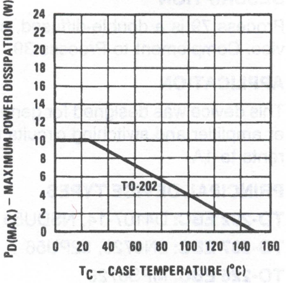
Safe Operating Area TO-202



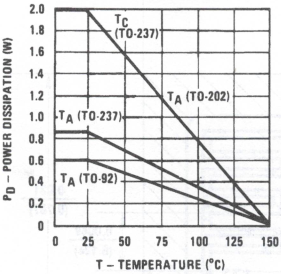
TL/G/10038–52

Process 78

Maximum Power Dissipation vs Case Temperature

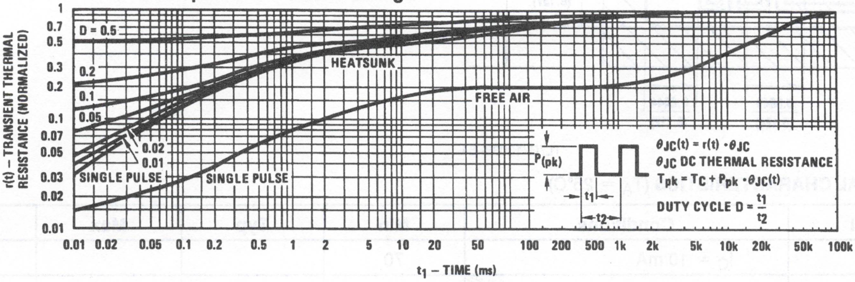


Thermal Derating Curve



TL/G/10038–51

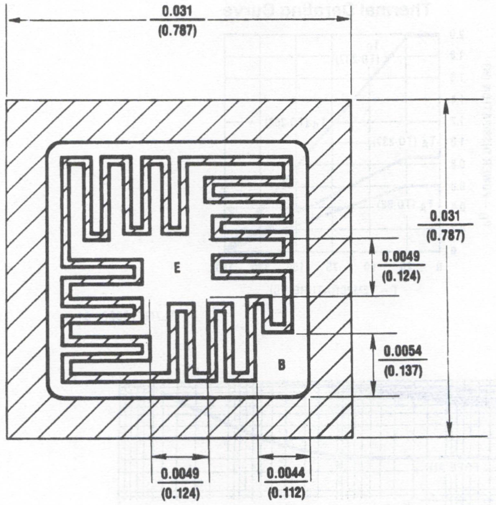
Thermal Response in TO-202 Package



TL/G/10038–53

National Semiconductor

Process 79
PNP Medium Power



TL/G/10038-54

DESCRIPTION

Process 79 is a double-diffused, silicon epitaxial planar device. Complement to Process 39.

APPLICATION

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1A.

PRINCIPAL DEVICE TYPES

TO-202 EBC: D4107-14, NSDU56
TO-237 EBC: 2N6729, 92PU56
TO-226 EBC: MPS6729
TO-92 EBC: PN6729

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

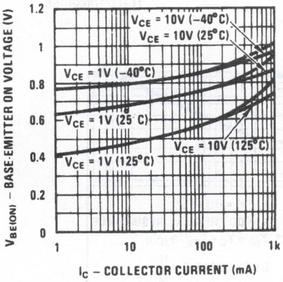
Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 10$ mA	70			V
BV_{CBO}	$I_C = 100\ \mu A$	80			V
BV_{EBO}	$I_E = 10\ \mu A$	5			V
I_{CBO}	$V_{CB} = 60V$			100	nA
I_{EBO}	$V_{EB} = 4V$			100	nA
h_{FE}	$I_C = 1$ mA, $V_{CE} = 1V$	40			
	$I_C = 100$ mA, $V_{CE} = 1V$	40	120	240	
	$I_C = 500$ mA, $V_{CE} = 1V$	20			
$V_{CE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			0.8	V
$V_{BE(SAT)}$	$I_C = 500$ mA, $I_B = 50$ mA			1.4	V
f_T	$I_C = 100$ mA, $V_{CE} = 10V$	70	125		MHz
C_{ob}	$V_{CB} = 10V$		14	18	pF
$P_{D(max)}$					
TO-202	$T_C = 25°C$	10			W
	$T_A = 25°C$	2			W
TO-226	$T_A = 25°C$	1			W
TO-237	$T_C = 25°C$	2			W
	$T_A = 25°C$	850			mW
TO-92	$T_A = 25°C$	600			mW
θ_{JC}					
TO-202	$T_C = 25°C$			12.5	°C/W
TO-237	$T_C = 25°C$			62.5	°C/W

Process 79

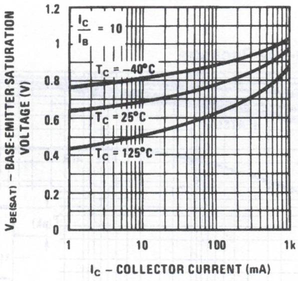
ELECTRICAL CHARACTERISTICS (T_A = 25°C) (Continued)

Symbol	Conditions	Min	Typ	Max	Units
θ_{JA}					
TO-126	T_A = 25°C			83.3	°C/W
TO-202	T_A = 25°C			62.5	°C/W
TO-226	T_A = 25°C			125	°C/W
TO-237	T_A = 25°C			147	°C/W
TO-92	T_A = 25°C			208	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

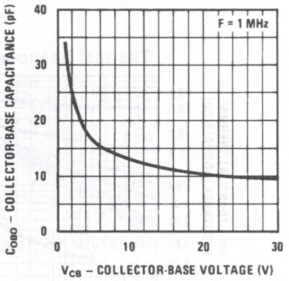
Base-Emitter ON Voltage vs Collector Current



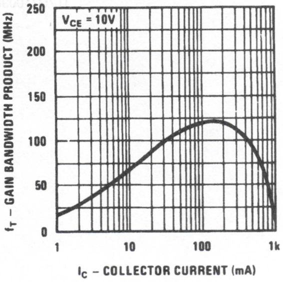
Base-Emitter Saturation Voltage vs Collector Current



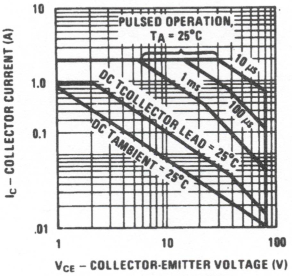
Collector-Base Capacitance vs Collector-Base Voltage



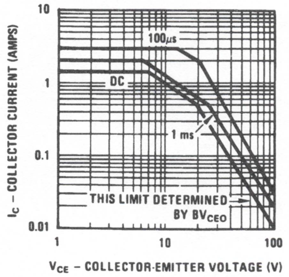
Gain Bandwidth Product vs Collector Current



Safe Operating Area TO-237

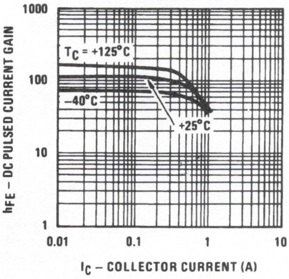


Safe Operating Area TO-202

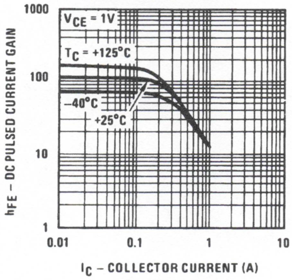


TL/G/10038–57

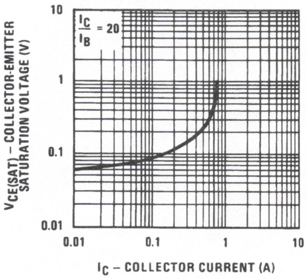
Pulsed Current Gain vs Collector Current



Pulsed Current Gain vs Collector Current

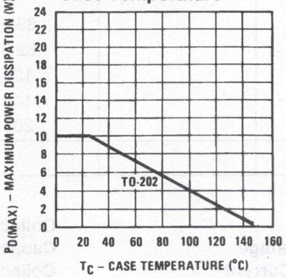


Collector-Emitter Saturation Voltage vs Collector Current

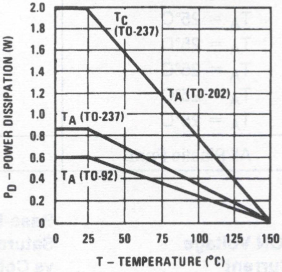


TL/G/10038–55

Maximum Power Dissipation vs Case Temperature

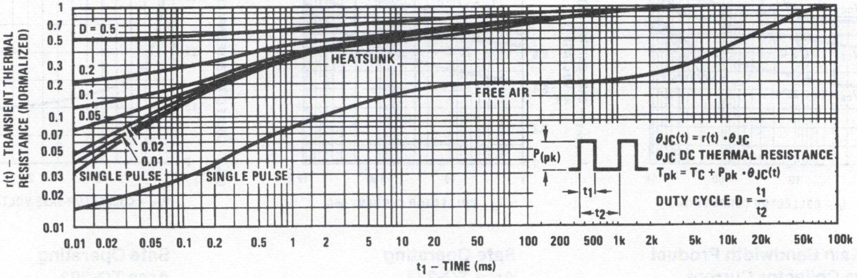


Thermal Derating Curve



TL/G/10038-56

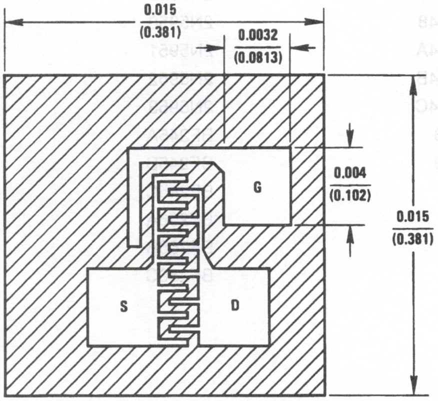
Thermal Response in TO-202 Package



TL/G/10038-58

National Semiconductor

Process 50
N-Channel JFET



TL/G/10035-1

Gate is also backside contact

DESCRIPTION

Process 50 is designed primarily for RF amplifier and mixer applications. It will operate up to 450 MHz with low noise figure and good power gain. These devices offer outstanding performance at VHF aircraft and communications frequencies. Their major advantage is low crossmodulation and intermodulation, low noise figure and good power gain. The device is also a good choice for analog switching where low capacitance is very important.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−25	−40		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 15V, V_{GS} = 0V$	1.0	10	20	mA
g_{fs}	Forward Transconductance	$V_{DS} = 15V, V_{GS} = 0V$	3.0	5.5	7.0	mmhos
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 200\ \mu A$		1.1		mmhos
I_{GSS}	Reverse Gate Leakage	$V_{GS} = -20V, V_{DS} = 0V$		−5.0	−100	pA
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100\ mV, V_{GS} = 0V$	100	175	500	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 15V, I_D = 1\ nA$	−0.7	−3.5	−6.0	V
g_{os}	Output Conductance	$V_{DG} = 15V, I_D = 1\ mA, f = 1\ kHz$		10		μmhos
C_{rss}	Feedback Capacitance	$V_{DG} = 15V, V_{GS} = 0V$		0.7	0.9	pF
C_{iss}	Input Capacitance	$V_{DS} = 15V, V_{GS} = 0V$		3.5	4.0	pF
e_n	Noise Voltage	$V_{DG} = 15V, I_D = 1\ mA, f = 100\ Hz$		8.0		$nV/\sqrt{Hz}$
NF	Noise Figure	$V_{DG} = 15V, I_D = 5\ mA,$ $R_G = 1\ k\Omega, f = 400\ MHz$		2.2	4.0	dB
G_{PS}	Power Gain	$V_{DG} = 15V, I_D = 5\ mA, f = 400\ MHz$		12		dB

Process 50

This process is available in the following device types. *Denotes preferred parts.

TO-72 (NS Package 29)

2N3823
2N3966
2N4223
2N4224
*2N4416
*2N4416A
2N5078
2N5103
2N5104
2N5105
2N5556
2N5557
2N5558

TO-92 (NS Package 92)

*2N5484
*2N5485
*2N5486
2N5555
2N5668
2N5669
2N5670
*J304
*J305
PN4223
PN4224
*PN4416
PN5163
MPF102
MPF106
MPF107
MPF110
MPF111

TO-92 (NS Package 94)

2N3819
2N5248
BF244A
BF244B
BF244C
TIS58
TIS59

TO-92 (NS Package 97)

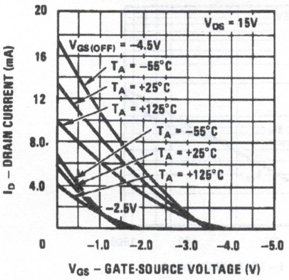
2N5949
2N5950
2N5951
2N5952
2N5953
BF245A
BF245B
BF245C
BF256A
BF256B
BF256C

TO-236/SOT23 (NS Package 48/49)

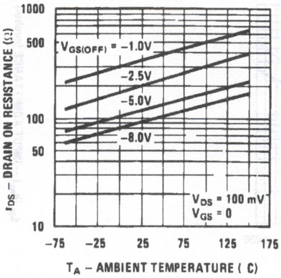
MMBFJ304
MMBFJ305
MMBF4416
MMBF5484
MMBF5485
MMBF5486

Process 50

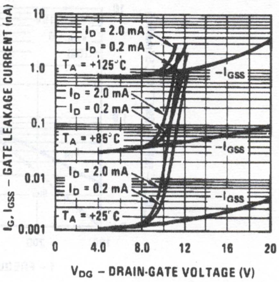
Transfer Characteristics



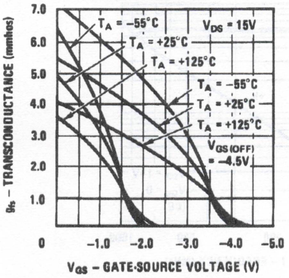
Channel Resistance vs Temperature



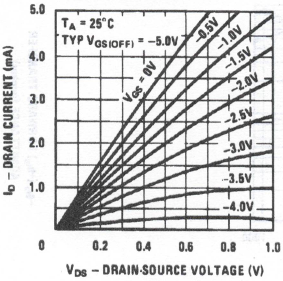
Leakage Current vs Voltage



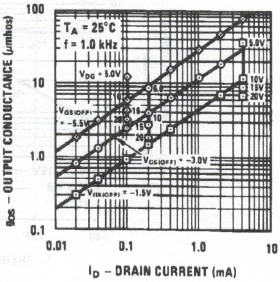
Transconductance Characteristics



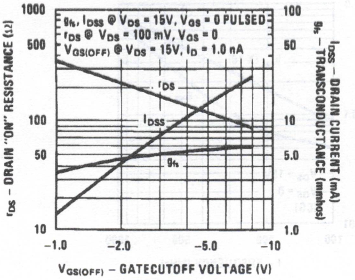
Common Drain-Source Characteristics



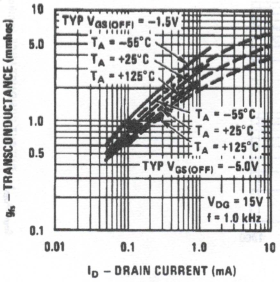
Output Conductance vs Drain Current



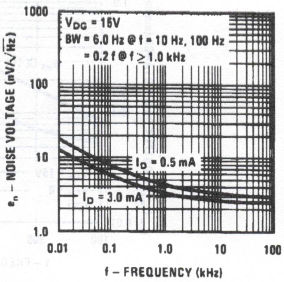
Parameter Interactions



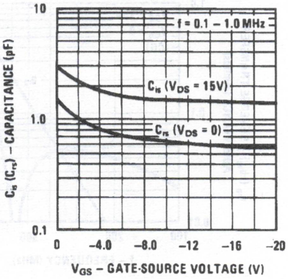
Transconductance vs Drain Current



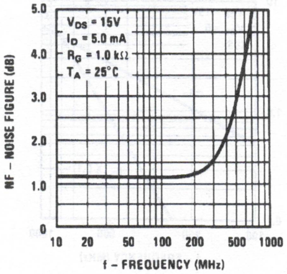
Noise Voltage vs Frequency



Capacitance vs Voltage



Noise Figure Frequency

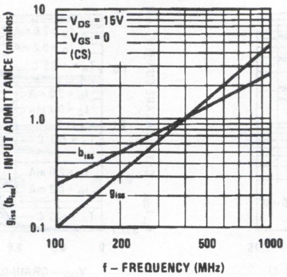


TL/G/10035-2

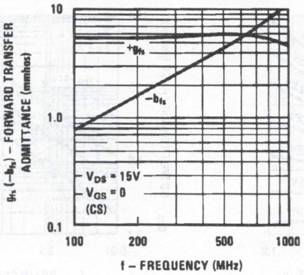
Process 50

COMMON SOURCE

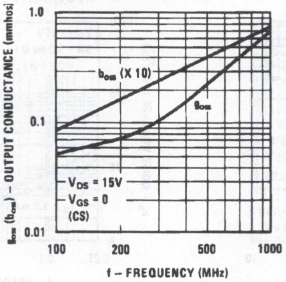
Input Admittance



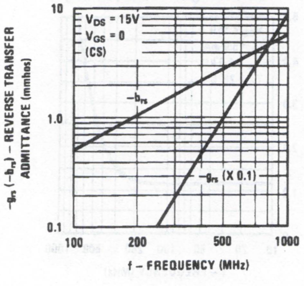
Forward Transadmittance



Output Admittance

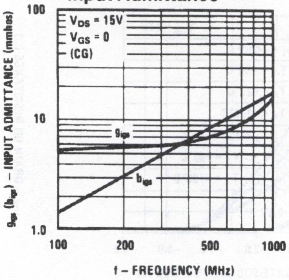


Reverse Transadmittance

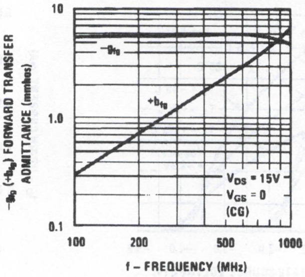


COMMON GATE

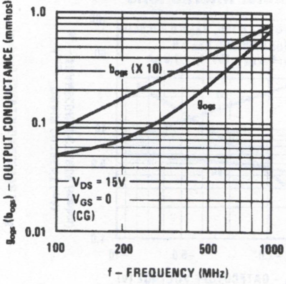
Input Admittance



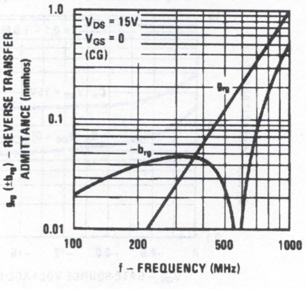
Forward Transadmittance



Output Admittance



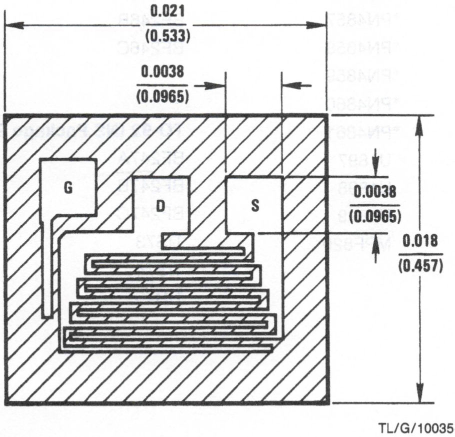
Reverse Transadmittance



TL/G/10035-3

National Semiconductor

Process 51
N-Channel JFET



TL/G/10035-4

Gate is also backside contact

DESCRIPTION

Process 51 is designed primarily for electronic switching applications such as low ON resistance analog switching. It features excellent C_{ISS} $R_{DS(ON)}$ time constant. The inherent zero offset voltage and low leakage current make these devices excellent for chopper stabilized amplifiers, sample and hold circuits, and reset switches. Low feed-through capacitance also allows them to handle video signals to 100 MHz.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−30	−45		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 20V, V_{GS} = 0V$ Pulse Test	5.0	65	170	mA
I_{GSS}	Reverse Gate Leakage	$V_{GS} = -20V, V_{DS} = 0V$		−15	−200	pA
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100\ mV, V_{GS} = 0V$	20	35	100	Ω
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 2\ mA$			8.5	mmhos
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 20V, I_D = 1\ nA$	−0.5	−4.5	−9.0	V
$I_{D(OFF)}$	Drain OFF Current	$V_{DS} = 20V, V_{GS} = -10V$		15	200	pA
C_{rss}	Feedback Capacitance	$V_{DG} = 15V, I_D = 5\ mA, f = 1\ MHz$		3.5	4.0	pF
C_{iss}	Input Capacitance	$V_{DG} = 15V, I_D = 5\ mA, f = 1\ MHz$		10	16	pF
e_n	Noise Voltage	$V_{DG} = 15V, I_D = 1\ mA, f = 100\ Hz$		6.0		$nV/\sqrt{Hz}$
t_{on}	Turn-On Time	$V_{DD} = 10V, I_D = 6.6\ mA$		12	20	ns
t_{off}	Turn-Off Time	$V_{DD} = 10V, I_D = 6.6\ mA$		40	80	ns

Process 51

This process is available in the following device types. *Denotes preferred parts.

TO-18 (NS Package 02)

2N3970
2N3971
2N3972
*2N4091
*2N4092
*2N4093
*2N4391
*2N4392
*2N4393
*2N4856
2N4856A
*2N4857
2N4857A
*2N4858
2N4858A
*2N4859
2N4859A
2N4860
2N4860A
2N4861
2N4861A

TO-92 (NS Package 92)

*2N5638
*2N5639
*2N5640
2N5653
2N5654
*J111
*J112
*J113
*PF5101
*PF5102
*PF5103
*PN4091
*PN4092
*PN4093
*PN4391
*PN4392
*PN4393
*PN4856
*PN4857
*PN4858
*PN4859
*PN4860
*PN4861
U1897
U1898
U1899
MPF820

TO-92 (NS Package 94)

BF246A
BF246B
BF246C

TO-92 (NS Package 97)

BF247A
BF247B
BF247C
TIS73
TIS74
TIS75

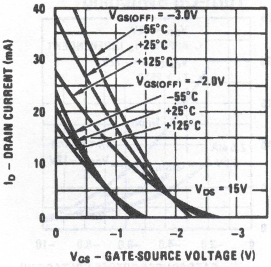
Source and drain interchangeable.

TO-236/SOT23 (NS Package 48/49)

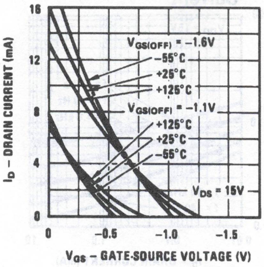
MMBFJ111
MMBFJ112
MMBFJ113
MMBF4391
MMBF4392
MMBF4393

Process 51

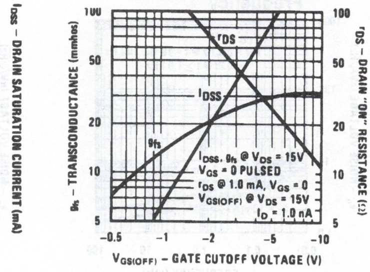
Transfer Characteristics



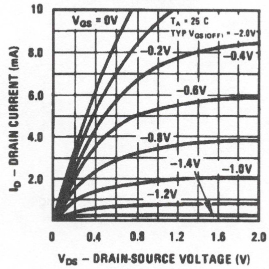
Transfer Characteristics



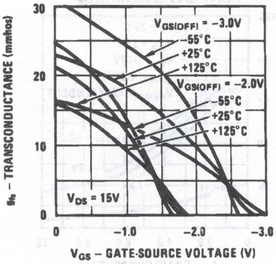
Parameter Interactions



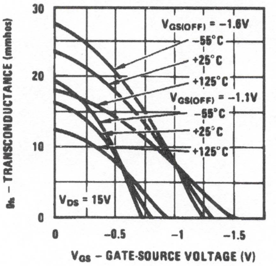
Common Drain-Source Characteristics



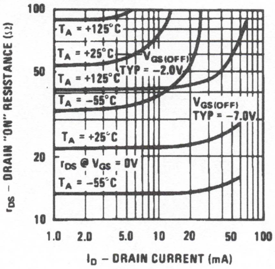
Transfer Characteristics



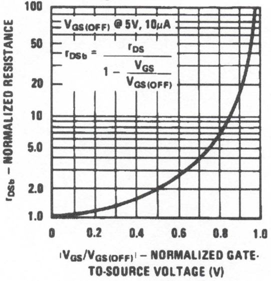
Transfer Characteristics



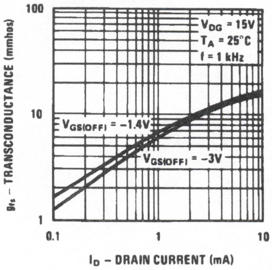
Resistance vs Drain Current



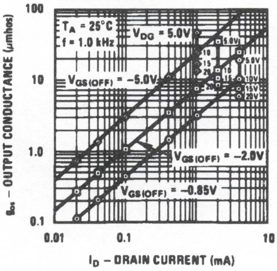
Normalized Drain Resistance vs Bias Voltage



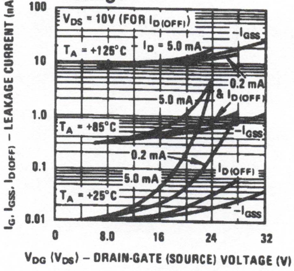
Transconductance vs Drain Current



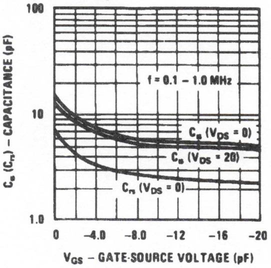
Output Conductance vs Drain Current



Leakage Current vs Voltage



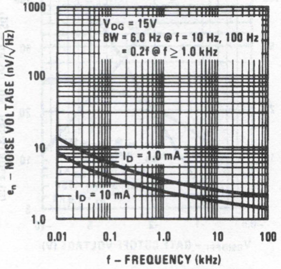
Capacitance vs Voltage



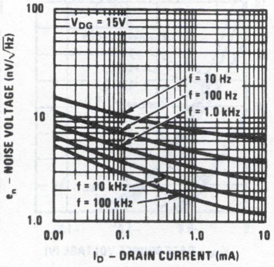
TL/G/10035-5

Process 51

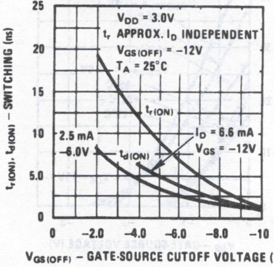
Noise Voltage vs Frequency



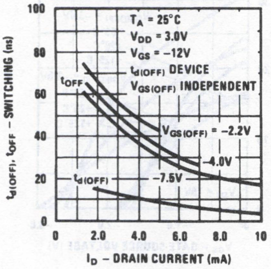
Noise Voltage vs Current



Turn-On Switching



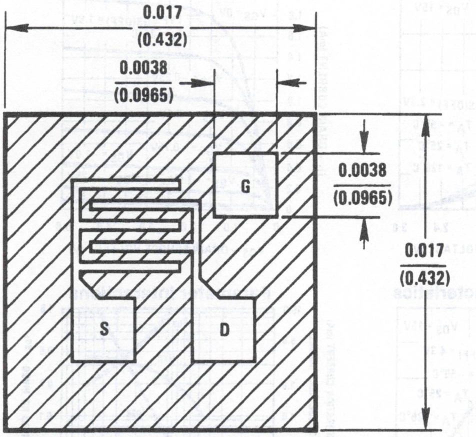
Turn-Off Switching



TL/G/10035-6

National Semiconductor

Process 52
N-Channel JFET



TL/G/10035-7

Gate is also backside contact

DESCRIPTION

Process 52 is designed primarily for low level audio and general purpose applications. These devices provide excellent performance as input stages for piezoelectric transducers or other high impedance signal sources. Their high output impedance and high voltage breakdown lend them to high gain audio and video amplifier applications. Source and drain are interchangeable.

Electrical Characteristics ($T_A = 25°C$)

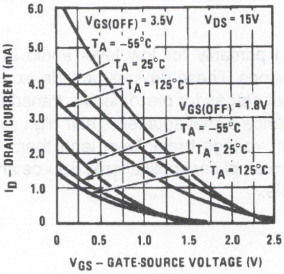
Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−40	−70		V
I_{DSS}	Drain Saturation Current	$V_{DS} = 20V, V_{GS} = 0V$	0.2	1.5	12	mA
g_{fs}	Forward Transconductance	$V_{DS} = 20V, V_{GS} = 0V$	0.5	2.5	5.0	mmho
g_{fs}	Forward Transconductance	$V_{DS} = 20V, I_D = 200\ \mu A$		700		μmho
I_{GSS}	Reverse Gate Leakage Current	$V_{GS} = -30V, V_{DS} = 0V$		−10	−100	pA
$r_{DS(ON)}$	Drain ON Resistance	$V_{DS} = 100\ mV, V_{GS} = 0V$	250	400	2000	Ω
$V_{GS(OFF)}$	Gate Cutoff Voltage	$V_{DS} = 15V, I_D = 1\ nA$	−0.3	1.0	−8.0	V
g_{os}	Output Conductance	$V_{DG} = 15V, I_D = 200\ \mu A$		2.0		μmho
C_{rss}	Feedback Capacitance	$V_{DG} = 15V, V_{GS} = 0V, f = 1\ MHz$		1.3	1.8	pF
C_{iss}	Input Capacitance	$V_{DG} = 15V, V_{GS} = 0V, f = 1\ MHz$		5	6	pF
e_n	Noise Voltage	$V_{DG} = 15V, I_D = 200\ \mu A, f = 100\ Hz$		10		$nV/\sqrt{Hz}$

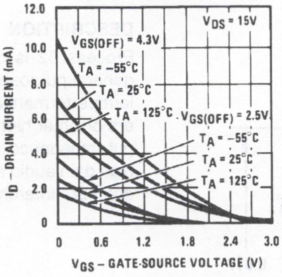
This process is available in the following device types. *Denotes preferred parts.

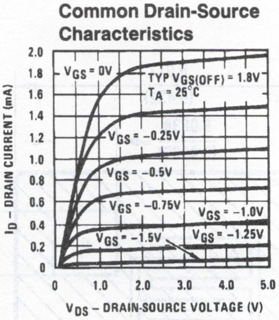
TO-18 (NS Package 02)	TO-72 (NS Package 25)	TO-92 (NS Package 92)
2N3070	*2N3684	*J201
2N3071	*2N3685	*J202
2N3368	*2N3686	*J203
2N3369	*2N3687	PN4338
2N3370		PN4339
2N3458		*PN3684
2N3459		*PN3685
2N3460		*PN3686
*2N4338		*PN3687
*2N4339		*PN4302
*2N4340		*PN4303
*2N4341		*PN4304

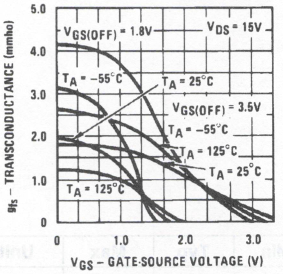
Source and drain interchangeable.

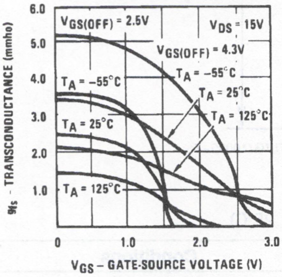
Process 52

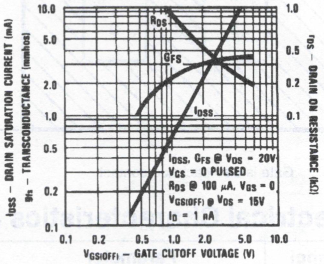

Transfer Characteristics

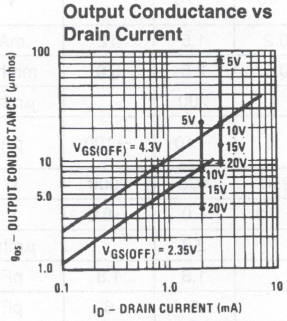

Transfer Characteristics

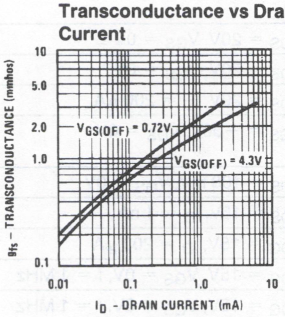

Common Drain-Source Characteristics

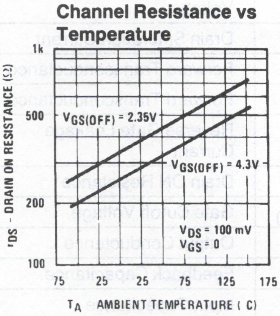

Transfer Characteristics

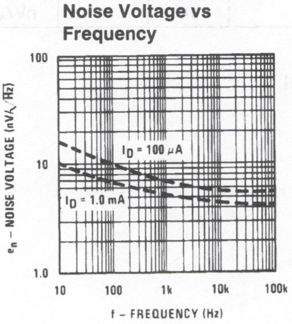

Transfer Characteristics

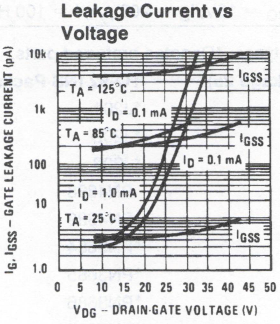

Parameter Interactions

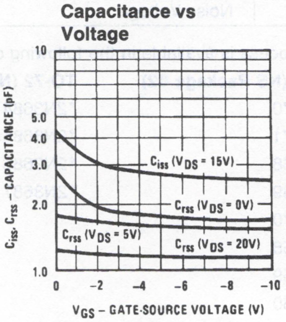

Output Conductance vs Drain Current


Transconductance vs Drain Current


Channel Resistance vs Temperature


Noise Voltage vs Frequency

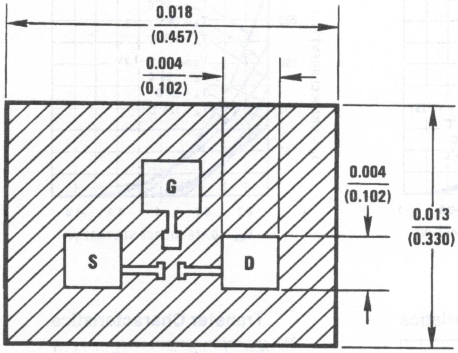

Leakage Current vs Voltage


Capacitance vs Voltage

TL/G/10035–8

National Semiconductor

Process 53
N-Channel JFET



TL/G/10035-9

Gate is also backside contact

DESCRIPTION

Process 53 is designed primarily for low current DC and audio applications. These devices provide excellent performance as input stages for sub-picoamp instrumentation or any high impedance signal sources.

Electrical Characteristics ($T_A = 25°C$)

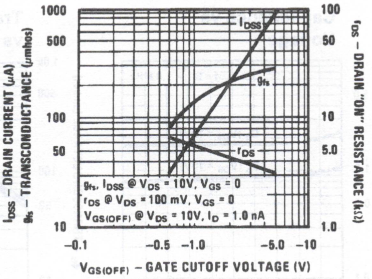
Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−40	−60		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 10V, V_{GS} = 0V$	0.02	0.25	1.0	mA
g_{fs}	Forward Transconductance	$V_{DS} = 10V, V_{GS} = 0V$	80	250	350	μmho
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 50\ \mu A$		120		μmho
I_{GSS}	Reverse Gate Leakage	$V_{GS} = -20V, V_{DS} = 0V$		−0.3	−10	pA
$V_{GS(Off)}$	Pinch Off Voltage	$V_{DS} = 10V, I_D = 1\ nA$	−0.5	−2.2	−6.0	V
C_{rss}	Feedback Capacitance	$V_{DG} = 15V, V_{GS} = 0V, f = 1\ MHz$		0.85	1.0	pF
C_{iss}	Input Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		2.0	2.5	pF
g_{os}	Output Conductance	$V_{DG} = 10V, I_D = 50\ \mu A$		0.9	5.0	μmhos
e_n	Noise Voltage	$V_{DG} = 10V, I_D = 50\ \mu A, f = 100\ Hz$		45	150	$nV/\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

TO-72 (NS Package 25)	TO-92 (NS Package 92)
2N4117	PN4117
*2N4117A	PN4117A
2N4118	PN4118
*2N4118A	PN4118A
2N4119	PN4119
*2N4119A	PN4119A
NF5301	PN4120
NF5301-1	PN4120A
NF5301-2	*PF5301
NF5301-3	PF5301-1
	PF5301-2
	PF5301-3

Source and drain interchangeable

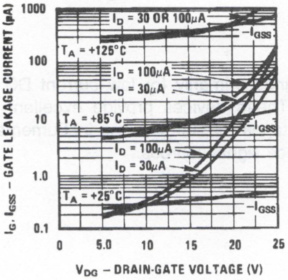
Parameter Interactions



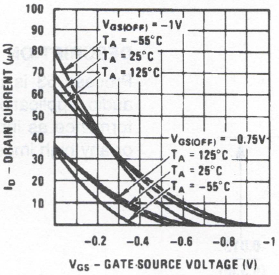
TL/G/10035-10

Process 53

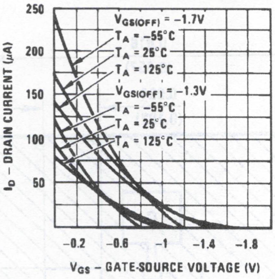
Leakage Current vs Voltage



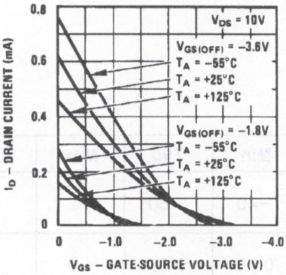
Transfer Characteristics



Transfer Characteristics



Transfer Characteristics



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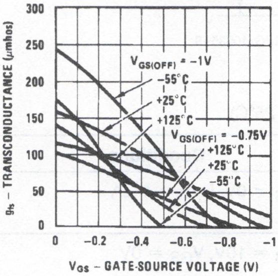
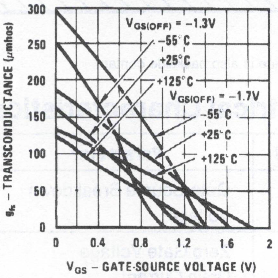
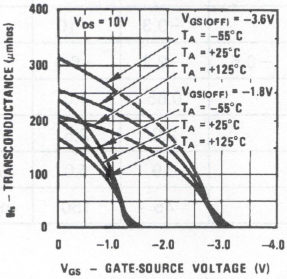


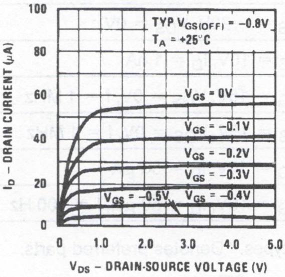
Transfer Characteristics



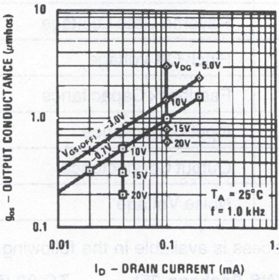
Transfer Characteristics



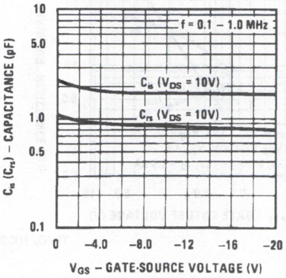
Common Drain-Source Characteristics



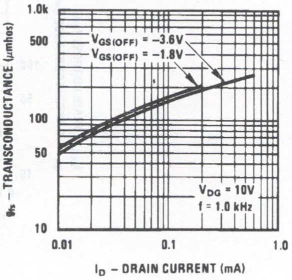
Output Conductance vs Drain Current



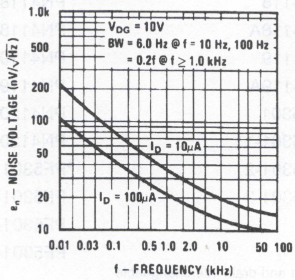
Capacitance vs Voltage



Transconductance vs Drain Current



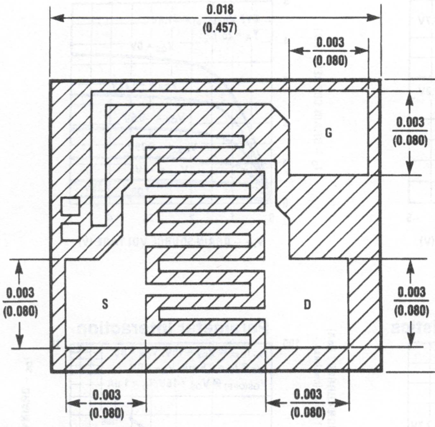
Noise Voltage vs Frequency



TL/G/10035–11

National Semiconductor

Process 55
N-Channel JFET



TL/G/10035-12

Gate is also backside contact

DESCRIPTION

Process 55 is a general purpose low level audio amplifier and switching transistor. Wafer processing is similar to process 52 but process 55 uses a larger geometry. This results in higher Y_{fs}, I_{DSS}, and capacitance and lower $R_{DS(ON)}$. It is useful for audio and video frequency amplifiers and RF amplifiers under 50 MHz. It may also be used for analog switching applications.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	V_{DS} = 0V, I_G = −1 μA	−40	−70		V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 20V, V_{GS} = 0V	0.5	5.0	20	mA
g_{fs}	Forward Transconductance	V_{DS} = 20V, V_{GS} = 0V	2.0	4.5	7.0	mmho
g_{fs}	Forward Transconductance	V_{DG} = 15V, I_D = 200 μA		1200		μmhos
I_{GSS}	Reverse Gate Leakage	V_{GS} = −30V, V_{DS} = 0V		−10	−100	pA
$r_{DS(ON)}$	ON Resistance	V_{DS} = 100 mV, V_{GS} = 0	140	250	600	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	V_{DS} = 20V, I_D = 1 nA	−0.5	−2.0	−8.0	V
C_{rss}	Feedback Capacitance	V_{DG} = 15V, V_{GS} = 0V, f = 1 MHz		1.5	2.0	pF
C_{iss}	Input Capacitance	V_{DS} = 15V, V_{GS} = 0V, f = 1 MHz		6.0	7.0	pF
g_{os}	Output Conductance	V_{DG} = 15V, I_D = 200 μA		2		μmhos
e_n	Noise Voltage	V_{DG} = 15V, I_D = 200 μA, f = 100 Hz		10		nV/$\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

TO-72 (NS Package 25)

2N3821
2N3822
2N3824
2N3967
2N3967A
2N3968
2N3968A
2N3969
2N3969A
2N4220
2N4220A
2N4221
2N4221A
2N4222
2N4222A
*2N5358
*2N5359
*2N5360
*2N5361
*2N5362
*2N5363
*2N5364

TO-92 (NS Package 92)

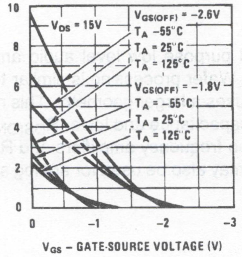
*2N5457
*2N5458
*2N5459
MPF103
MPF104
MPF105
MPF108
MPF109
MPF112
PN4220
PN4221
PN4222

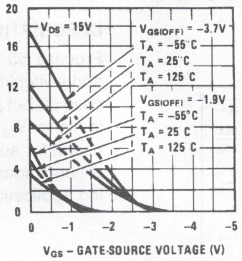
TO-236/SOT23 (NS Package 48/49)

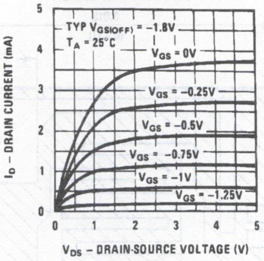
MMBF5457
MMBF5458
MMBF5459

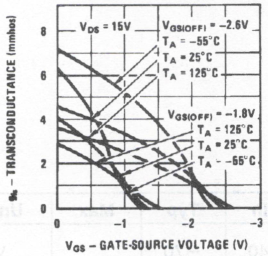
Source and drain interchangeable.

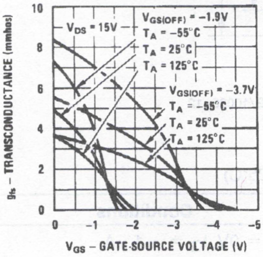
Process 55

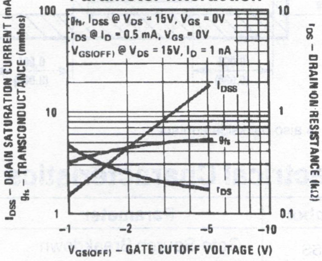

Transfer Characteristics

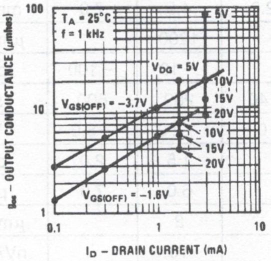

Transfer Characteristics

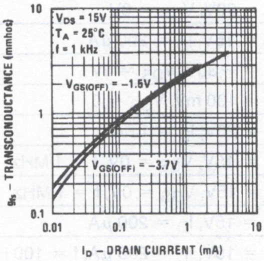

Common Drain-Source Characteristics

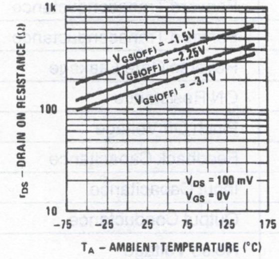

Transfer Characteristics

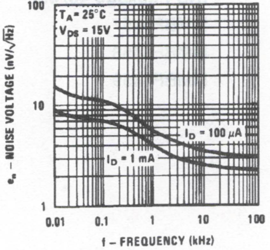

Transfer Characteristics

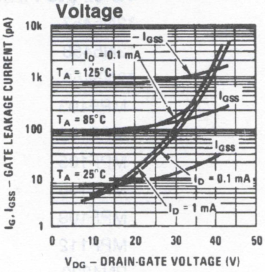

Parameter Interaction

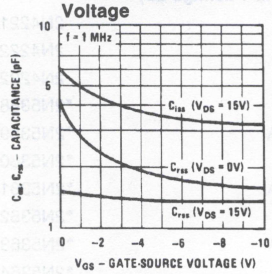

Output Conductance vs Drain Current


Transconductance vs Drain Current


Channel Resistance vs Temperature


Noise Voltage vs Frequency

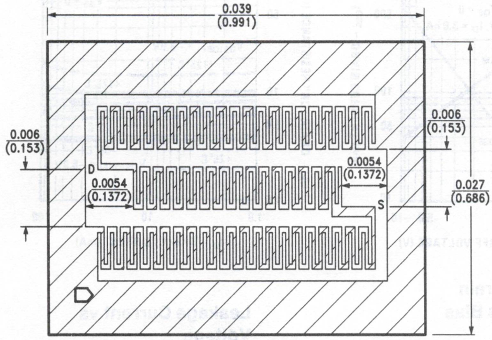

Leakage Current vs Voltage


Capacitance vs Voltage

TL/G/10035-13

National Semiconductor

Process 58
N-Channel JFET



TL/G/10035-14

Gate is also backside contact

DESCRIPTION

Process 58 was developed for analog or digital switching applications where very low $r_{DS(ON)}$ is mandatory. Switching times are very fast and $r_{DS(ON)}$ C_{iss} time constant is low. The 6Ω typical ON resistance is very useful in precision multiplex systems where switch resistance must be held to an absolute minimum. With r_{DS} increasing only 0.7%/°C, accuracy is retained over a wide temperature excursion.

Electrical Characteristics ($T_A = 25°C$)

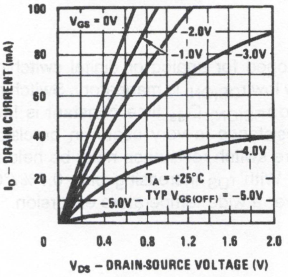
Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V$, $I_G = -1\ \mu A$	−25	−30		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 5V$, $V_{GS} = 0V$ Pulse Test	100	400	1000	mA
I_{GSS}	Reverse Gate Leakage	$V_{GS} = -15V$, $V_{DS} = 0V$		−50	−500	pA
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100\ mV$, $V_{GS} = 0V$	3.0	6.0	20	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 5V$, $I_D = 3\ nA$	−0.5	−5.0	−12	V
$I_{D(OFF)}$	Drain OFF Current	$V_{DS} = 5V$, $V_{GS} = -10V$		0.05	20	nA
C_{rss}	Feedback Capacitance	$V_{DG} = 15V$, $I_D = 2\ mA$, $f = 1\ MHz$		12	25	pF
C_{iss}	Input Capacitance	$V_{DG} = 15V$, $I_D = 2\ mA$, $f = 1\ MHz$		25	50	pF
g_{fs}	Forward Transconductance	$V_{DG} = 10V$, $I_D = 2\ mA$		10		mmhos
g_{os}	Output Conductance	$V_{DG} = 10V$, $I_D = 2\ mA$		100		μmhos
e_n	Noise Voltage	$V_{DG} = 15V$, $I_D = 2\ mA$, $f = 100\ Hz$		6.0		$nV/\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

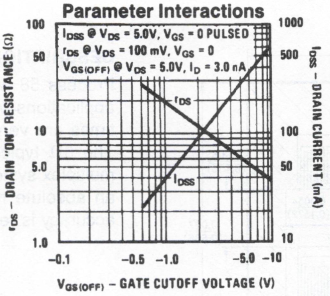
TO-52 (NS Package 07)	TO-92 (NS Package 92)
*2N5432	*J108
*2N5433	*J109
*2N5434	*J110
	PN5432
	PN5433
	PN5434

Process 58

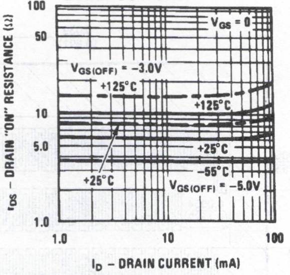
Common Drain-Source Characteristics



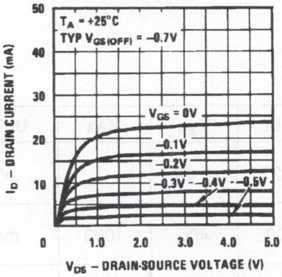
Parameter Interactions



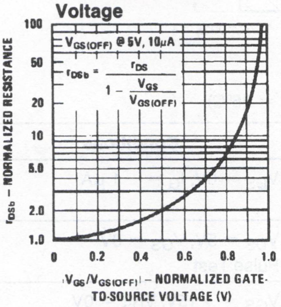
ON Resistance vs Drain Current



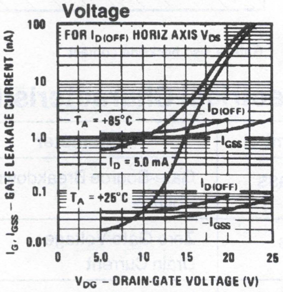
Common Drain-Source Characteristics



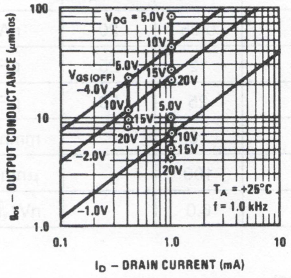
Normalized Drain Resistance vs Bias Voltage



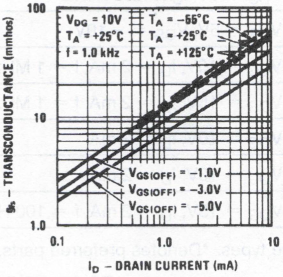
Leakage Current vs Voltage



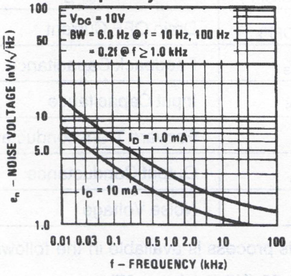
Output Conductance vs Drain Current



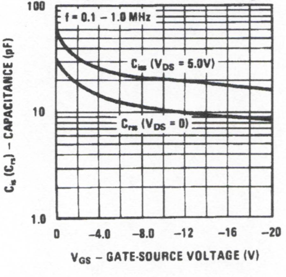
Transconductance vs Drain Current



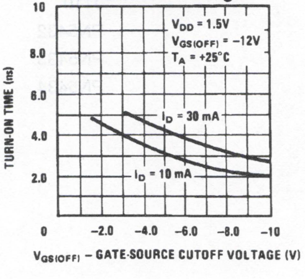
Noise Voltage vs Frequency



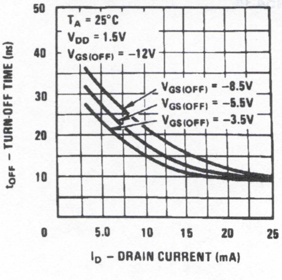
Capacitance vs Voltage



Switching Turn-On vs Gate-Source Voltage



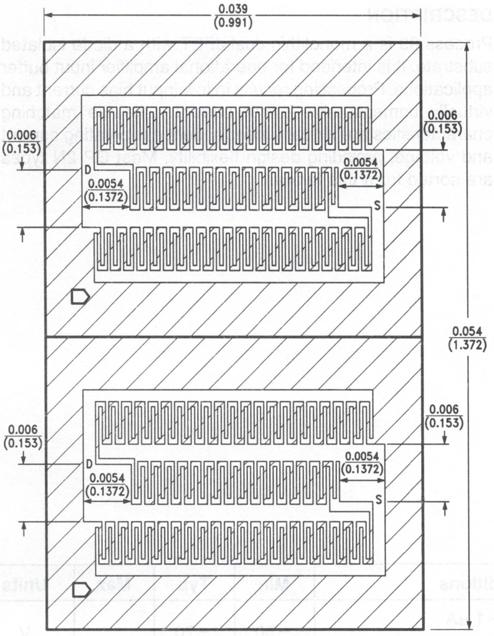
Switching Turn-On Time vs Drain Current



TL/G/10035–15

National Semiconductor

Process 59
N-Channel JFET



Gate is also backside contact

TL/G/10035-60

DESCRIPTION

Process 59 is provided for analog or digital switching applications where very low $R_{DS(ON)}$ is mandatory. The 4Ω typical ON resistance is very useful where switch resistance must be held to an absolute minimum.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\,\mu A$	25			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 15V, V_{GS} = 0V$ Pulse Test	100	600	1500	mA
I_{GSS}	Reverse Gate Leakage	$V_{GS} = -15V, V_{DS} = 0V$			1.0	nA
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100\text{ mV}, V_{GS} = 0V$	1.5	4.0	10	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 5V, I_D = 100\text{ nA}$	0.5	5.0	10	V
$I_{D(OFF)}$	Drain OFF Current	$V_{DS} = 5V, V_{GS} = -10V$		1.0	10	nA
C_{rss}	Feedback Capacitance	$V_{DG} = 15V, I_D = 2\text{ mA}, f = 1\text{ MHz}$		25	35	pF
C_{iss}	Input Capacitance	$V_{DG} = 15V, I_D = 2\text{ mA}, f = 1\text{ MHz}$		50	80	pF
g_{fs}	Forward Transconductance	$V_{DG} = 10V, I_D = 2\text{ mA}$		10		mmho
g_{os}	Output Conductance	$V_{DG} = 10V, I_D = 2\text{ mA}$		200		μmho
e_n	Noise Voltage	$V_{DG} = 15V, I_D = 2\text{ mA}, f = 100\text{ Hz}$		6.0		$nV/\sqrt{Hz}$

This process is available in the following device types.

TO-92 (NS Package 92)

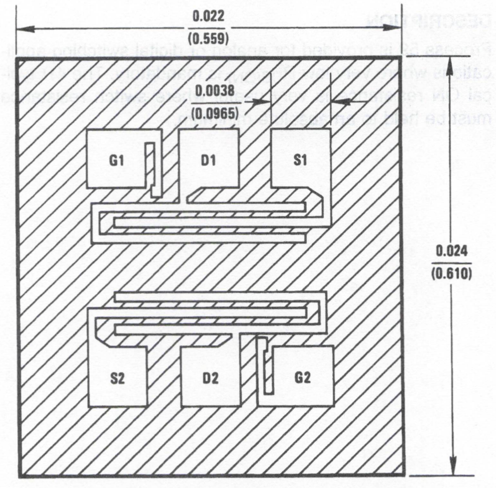
J105

J106

J107

National Semiconductor

Process 83
N-Channel Monolithic Dual JFET



TL/G/10035-16

DESCRIPTION

Process 83 is a monolithic dual JFET with a diode isolated substrate. It is intended for operational amplifier input buffer applications. Processing results in low input bias current and virtually unmeasurable offset current. Likewise matching characteristics are virtually independent of operating current and voltage, providing design flexibility. Most GP 2N types are sorted from this family.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−50	−70		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 15V, V_{GS} = 0V$	0.5	2.5	8.0	mA
g_{fs}	Forward Transconductance	$V_{DS} = 15V, V_{GS} = 0V$	1.0	2.5	5.0	mmho
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 15V, I_D = 1\ nA$	−0.5	−2.0	−4.5	V
I_G	Gate Current	$V_{DG} = 20V, I_D = 0.2\ mA$		3.0	50	pA
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 0.2\ mA$	600	850		μmhos
g_{os}	Output Conductance	$V_{DG} = 15V, I_D = 0.2\ mA$		1.0	5.0	μmhos
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100\ mV, V_{GS} = 0V$		450		Ω
e_n	Noise Voltage	$V_{DG} = 15V, I_D = 0.2\ mA, f = 100\ Hz$		10	50	$nV/\sqrt{Hz}$
$\lvert V_{GS1} - V_{GS2} \rvert$	Differential Match	$V_{DG} = 15V, I_D = 0.2\ mA$		7.0	25	mV
$\Delta V_{GS1} - V_{GS2}$	Differential Match Drift	$V_{DG} = 15V, I_D = 0.2\ mA$		10	50	$\mu V/°C$
CMRR	Common-Mode Rejection	$V_{DG} = 15V, I_D = 0.2\ mA$	80	95		dB
C_{rs}	Feedback Capacitance	$V_{DG} = 15V, I_D = 0.2\ mA, f = 1\ MHz$		1.0	1.2	pF
C_{is}	Input Capacitance	$V_{DG} = 15V, I_D = 0.2\ mA, f = 1\ MHz$		3.4	4.0	pF

Process 83

This process is available in the following device types. *Denotes preferred parts.

TO-71 (NS Package 12)

*2N3954
*2N3954A
*2N3955
*2N3955A
*2N3956
*2N3957
*2N3958
2N5045
2N5046
2N5047

*2N5196
*2N5197
*2N5198
*2N5199
2N5452
2N5453
2N5454
*2N5545
*2N5546
*2N5547

U231
U232
U233
U234
U235

Note: S0-8 to be announced.

8-Pin MiniDIP (NS Package 60)

J410
J411
J412

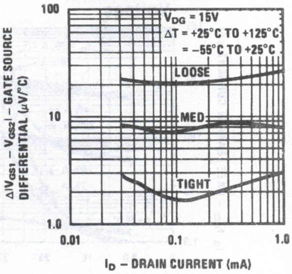
Pin	60
1	NC
2	S1
3	D1
4	G1
5	S2
6	D2
7	G2
8	NC

8-Pin MiniDIP (NS Package 67)

*NPD8301
*NPD8302
*NPD8303
*NPD8304

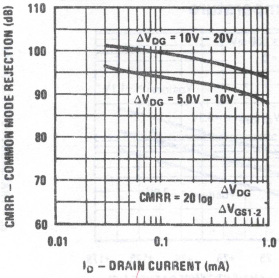
Pin	67
1	S1
2	D1
3	NC
4	G1
5	S2
6	D2
7	NC
8	G2

Differential Drift



TL/G/10035-18

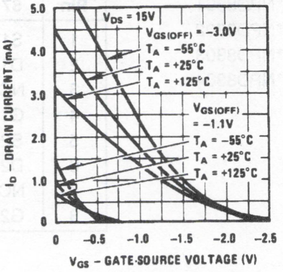
CMRR vs Drain Current



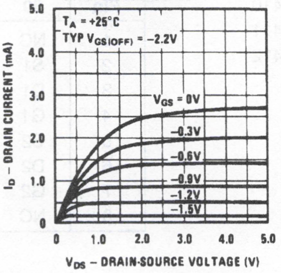
TL/G/10035-19

Process 83

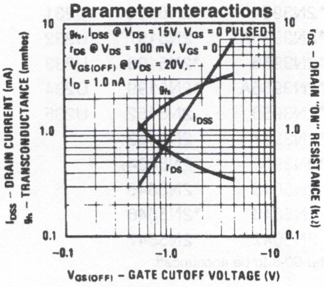
Transfer Characteristics



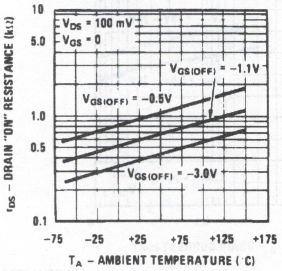
Common Drain-Source Characteristics



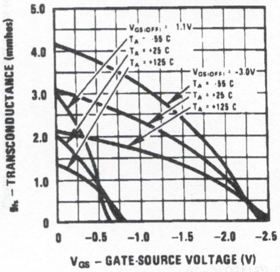
Parameter Interactions



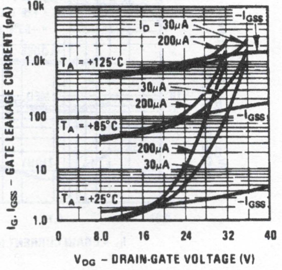
Channel Resistance vs Temperature



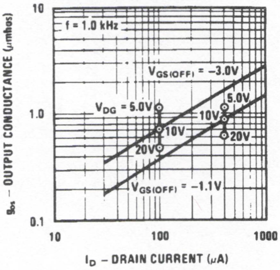
Transfer Characteristics



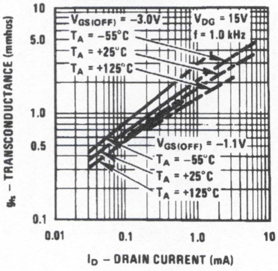
Leakage Current vs Voltage



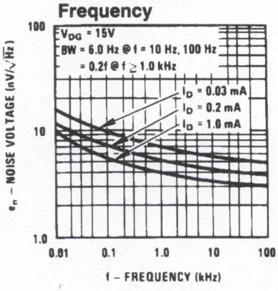
Output Conductance vs Drain Current



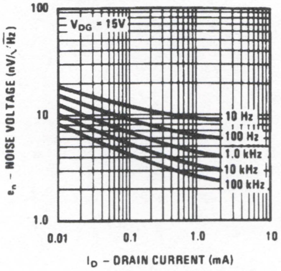
Transconductance vs Drain Current



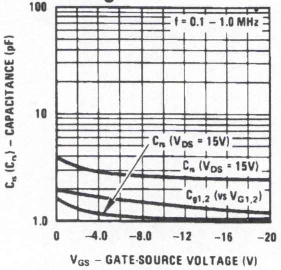
Noise Voltage vs Frequency



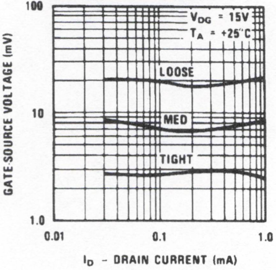
Noise Voltage vs Current



Capacitance vs Voltage



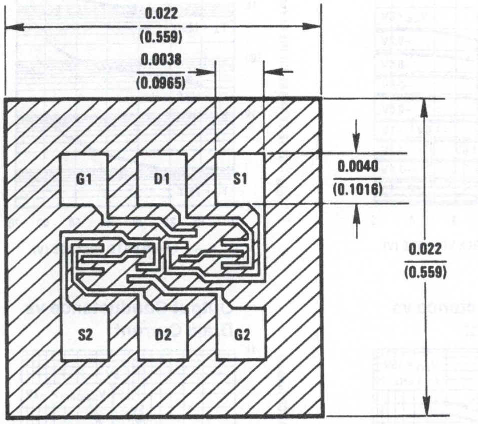
Differential Offset



TL/G/10035–17

National Semiconductor

Process 84
N-Channel Monolithic Dual JFET



TL/G/10035-20

DESCRIPTION

Process 84 is a monolithic dual JFET with a diode isolated substrate. It is designed for the most critical operational amplifier input stages or electrometer single ended preamp. Ideal for medical applications and instrumentation inputs where sub-picoamp inputs are important. Device design considered high CMRR, sub-picoamp leakage over wide input swings, low capacitance, and tight match over wide current range.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−40	−60		V
I_{DSS}	Drain Saturation Current	$V_{DS} = 15V, V_{GS} = 0V$	20	300	1000	μA
g_{fs}	Forward Transconductance	$V_{DS} = 15V, V_{GS} = 0V$	90	180	300	μmhos
g_{fs}	Forward Transconductance	$V_{DS} = 15V, I_D = 30\ \mu A$	50	120	150	μmhos
$V_{GS(OFF)}$	Gate Cutoff Voltage	$V_{DS} = 15V, I_D = 1\ nA$	0.5	2	4.5	V
I_{GSS}	Reverse Gate Leakage Current	$V_{DS} = 0V, V_{GS} = -20V$		1	5	pA
I_G	Gate Leakage Current	$V_{DG} = 10V, I_D = 30\ \mu A$		0.5	3	pA
C_{rss}	Feedback Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		0.3	0.4	pF
C_{iss}	Input Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		2	3	pF
e_n	Noise Voltage	$V_{DS} = 15V, I_D = 30\ \mu A, f = 1\ kHz$		30	50	$nV/\sqrt{Hz}$
e_n	Noise Voltage	$V_{DS} = 15V, I_D = 30\ \mu A, f = 10\ Hz$		180		$nV/\sqrt{Hz}$
g_{os}	Output Conductance	$V_{DS} = 10V, I_D = 30\ \mu A$		0.01	0.1	μmhos
$\|V_{GS1}-V_{GS2}\|$	Differential Gate-Source Voltage	$V_{DS} = 10V, I_D = 30\ \mu A$		12	25	mV
$\Delta V_{GS1}-V_{GS2}$	Differential Gate-Source Voltage Drift	$V_{DS} = 10V, I_D = 30\ \mu A$		10	50	μV/°C
CMRR	Common-Mode Rejection Ratio	$V_{DS} = 10V, I_D = 30\ \mu A$		112		dB

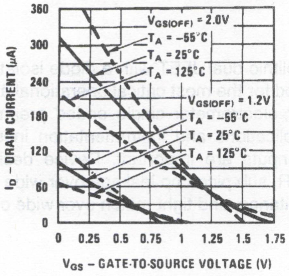
This process is available in the following device types. *Denotes preferred parts.

TO-78 (NS Package 24)

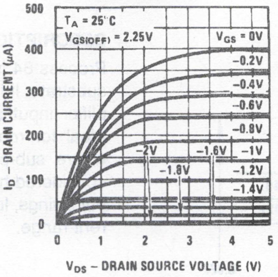
2N5902	*2N5906
2N5903	*2N5907
2N5904	*2N5908
2N5905	*2N5909

Process 84

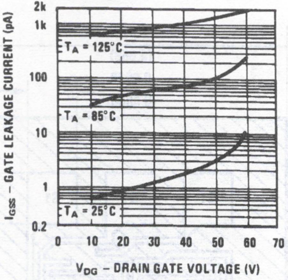
Transfer Characteristics



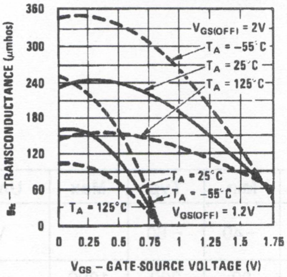
Common Drain-Source Characteristics



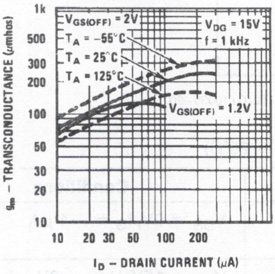
Leakage Current vs Voltage



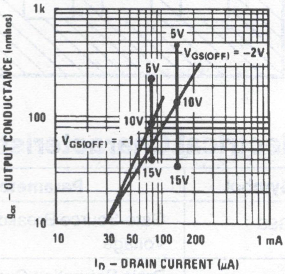
Transfer Characteristics



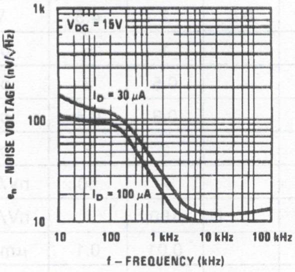
Transconductance vs Drain Current



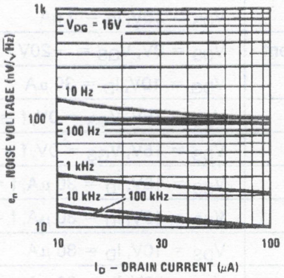
Output Conductance vs Drain Current



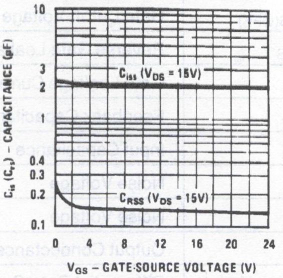
Noise Voltage vs Frequency



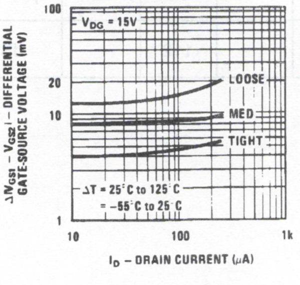
Noise Voltage vs Current



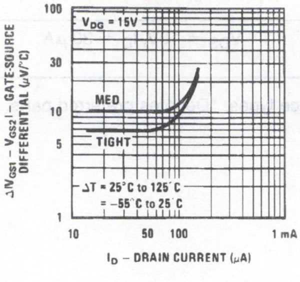
Capacitance vs Voltage



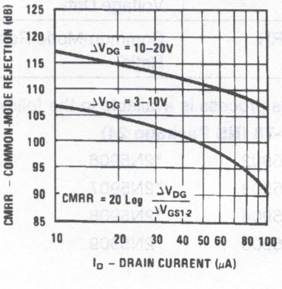
Differential Offset



Differential Drift



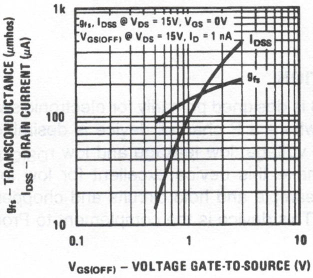
CMRR vs Drain Current



TL/G/10035–23

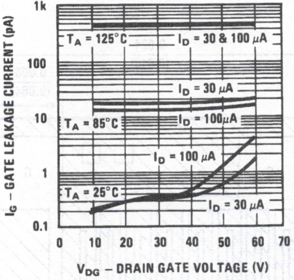
Process 84

Parameter Interactions



TL/G/10035-21

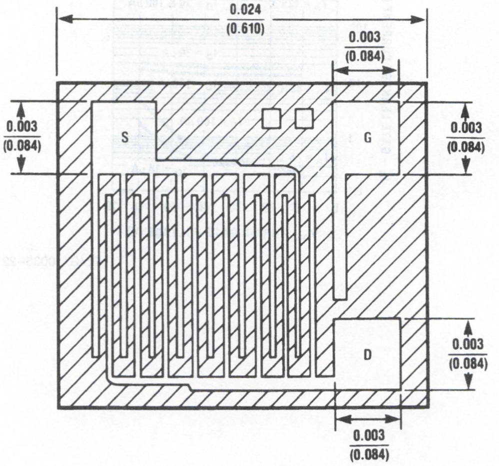
Leakage Current vs Voltage and Drain Current



TL/G/10035-22

National Semiconductor

Process 88
P-Channel JFET



TL/G/10035-25

Gate is also backside contact

DESCRIPTION

Process 88 is designed primarily for electronic switching applications where a P channel device is desirable. Inherent zero offset voltage, low leakage and low $r_{DS(ON)}$ C_{iss} time constant make this device excellent for low level analog switching, sample and hold circuits and chopper stabilized amplifiers. This device is the complement to Process 51.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V$, $I_G = 1\ \mu A$	30	40		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = -15V$, $V_{GS} = 0V$	−5.0	−30	−90	mA
g_{fs}	Forward Transconductance	$V_{DS} = -15V$, $V_{GS} = 0V$	4.0	13	17	mmhos
g_{fs}	Forward Transconductance	$V_{DG} = -15V$, $I_D = -2$ mA		3.5		mmhos
I_{GSS}	Gate Leakage	$V_{GS} = 20V$, $V_{DS} = 0V$		0.05	1.0	nA
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100$ mV, $V_{GS} = 0V$	50	80	200	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = -15V$, $I_D = -1$ nA	0.5	5.0	10	V
$I_{D(OFF)}$	Drain OFF Current	$V_{DS} = -15V$, $V_{GS} = 10V$		−0.05	−10	nA
C_{rss}	Feedback Capacitance	$V_{DG} = -15V$, $I_D = -2$ mA, f = 1 MHz		4.0	5.0	pF
C_{iss}	Input Capacitance	$V_{DS} = -15V$, $I_D = -2$ mA, f = 1 MHz		14	15	pF
g_{os}	Output Conductance	$V_{DG} = -15V$, $I_D = -2$ mA		100	300	µmhos
e_n	Noise Voltage	$V_{DG} = -15V$, $I_D = -2$ mA, f = 100 Hz		20		nV/$\sqrt{Hz}$

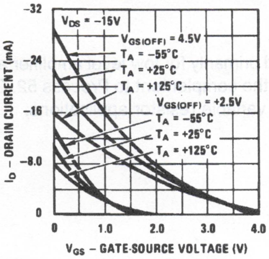
This process is available in the following device types. *Denotes preferred parts.

TO-18 (NS Package 11)	TO-92 (NS Package 92)	TO-92 (NS Package 94)	TO-236/SOT23 (NS Package 48/49)
2N2609	*P1086	*J174	MMBFJ174
2N5018	*P1087	*J175	MMBFJ175
2N5019		*J176	MMBFJ176
*2N5114		*J177	MMBFJ177
*2N5115		*J270	
*2N5116		*J271	

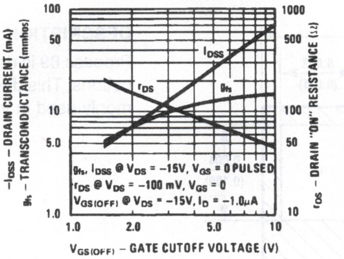
Source and drain interchangeable.

Process 88

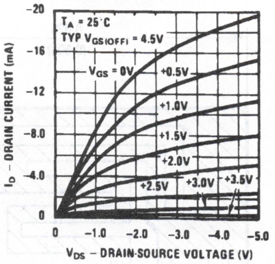
Transfer Characteristics



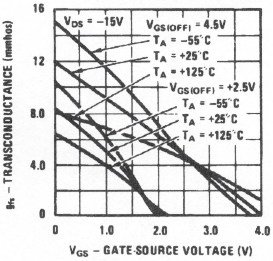
Parameter Interactions



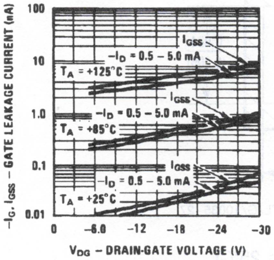
Common Drain-Source Characteristics



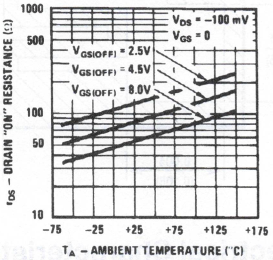
Transfer Characteristics



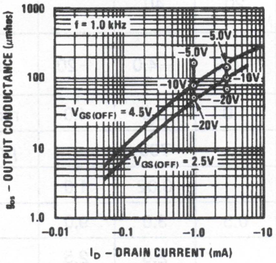
Leakage Current vs Voltage



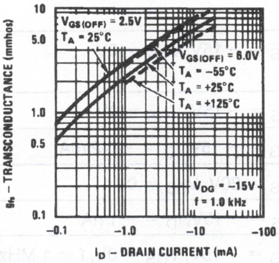
Channel Resistance vs Temperature



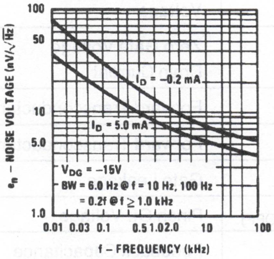
Output Conductance vs Drain Current



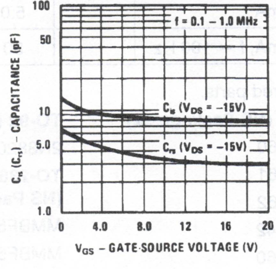
Transconductance vs Drain Current



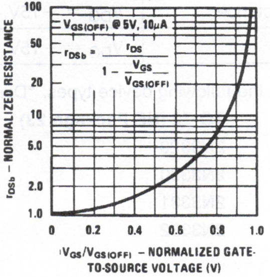
Noise Voltage vs Frequency



Capacitance vs Voltage



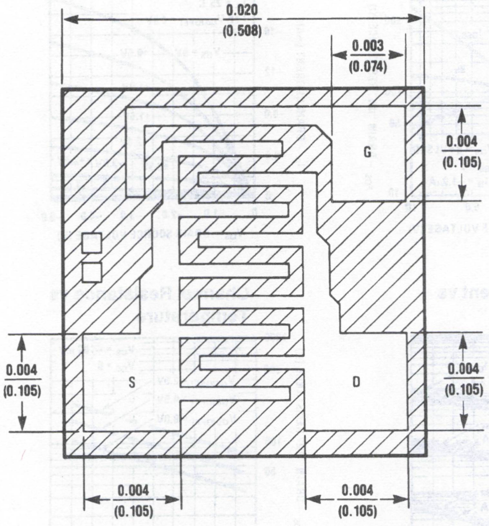
Normalized Drain Resistance vs Bias Voltage



TL/G/10035–26

National Semiconductor

Process 89
P-Channel JFET



TL/G/10035-27

DESCRIPTION

Process 89 is designed primarily for low level amplifier applications. This device is the complement to Process 52. Commonly used in voltage variable resistor applications.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = 1\ \mu A$	20	40		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = -15V, V_{GS} = 0V$	−0.3	−4.0	−20	mA
g_{fs}	Forward Transconductance	$V_{DS} = -15V, V_{GS} = 0V$	1.0	2.5	4.0	mmhos
g_{fs}	Forward Transconductance	$V_{DG} = -15V, I_D = -0.2\ mA$		700		µmhos
I_{GSS}	Gate Leakage	$V_{GS} = 20V, V_{DS} = 0V$		0.02	1.0	nA
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = -15V, I_D = -1\ nA$	0.5	3.0	9.0	V
C_{rss}	Feedback Capacitance	$V_{DG} = -15V, V_{GS} = 0V, f = 1\ MHz$		2.0	2.5	pF
C_{is}	Input Capacitance	$V_{DS} = -15V, I_D = -2\ mA, f = 1\ MHz$		7.0	8.5	pF
$r_{DS(ON)}$	ON Resistance	$V_{DS} = -100\ mV, V_{GS} = 0V$		450		Ω
g_{os}	Output Conductance	$V_{DG} = -15V, I_D = -0.2\ mA$		5.0	15	µmhos
e_n	Noise Voltage	$V_{DG} = -15V, I_D = -0.2\ mA, f = 100\ Hz$		30		$nV/\sqrt{Hz}$

This process is available in the following device types. *Denotes preferred parts.

TO-18 (NS Package 11)
2N2608
2N4381
2N5020
2N5021

TO-72 (NS Package 23)
2N3329
2N3330
2N3331
2N3332

TO-92 (NS Package 92)
*2N5460
*2N5461
*2N5462
PN4342
PN4360
PN5033

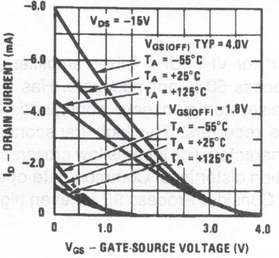
TO-92 (NS Package 94)
2N3820

TO-236/SOT23 (NS Package 48/49)
MMBF5460
MMBF5461
MMBF5462

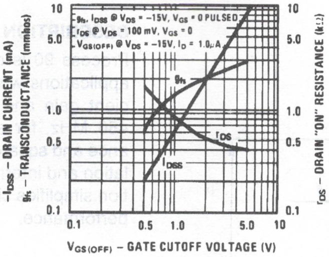
Source and drain interchangeable.

Process 89

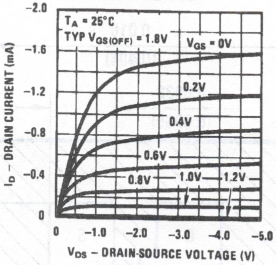
Transfer Characteristics



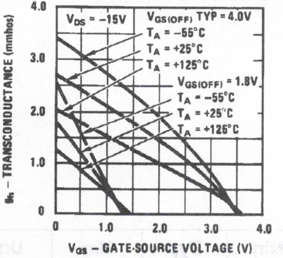
Parameter Interactions



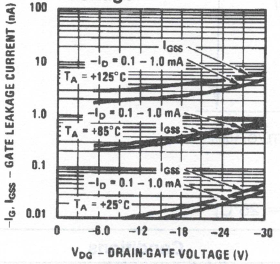
Common Drain-Source Characteristics



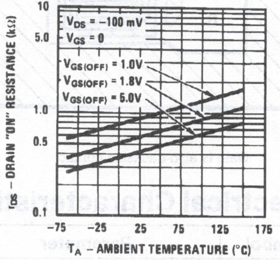
Transfer Characteristics



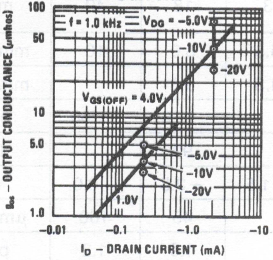
Leakage Current vs Voltage



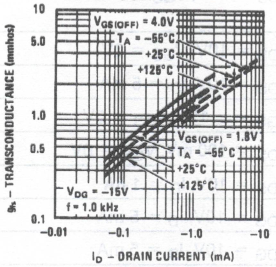
Channel Resistance vs Temperature



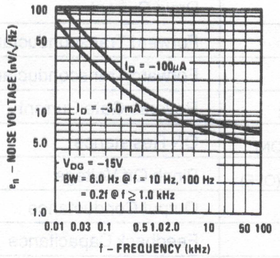
Output Conductance vs Drain Current



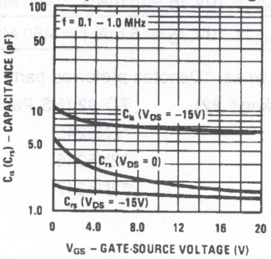
Transconductance vs Drain Current



Noise Voltage vs Frequency



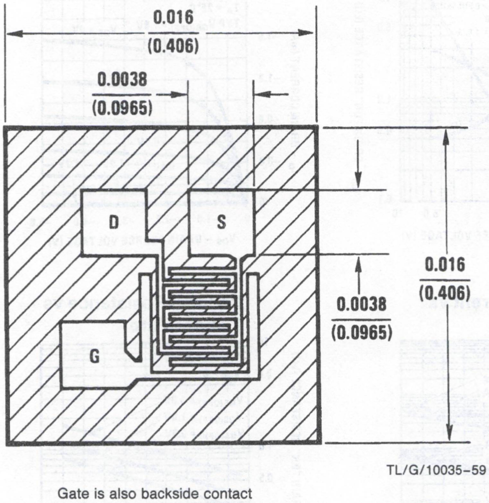
Capacitance vs Voltage



TL/G/10035–28

National Semiconductor

Process 90
N-Channel JFET



Gate is also backside contact

DESCRIPTION

Process 90 is designed for VHF/UHF mixer/amplifier and applications where Process 50 is not adequate. Has sufficient gain and low noise, common gate configuration at 450 MHz, for sensitive receivers. The high transconductance and square law characteristics insures low crossmodulation and intermodulation distortions. Common-gate operation simplifies circuitry. Consider Process 92 for even higher performance.

Electrical Characteristics ($T_A = 25°C$)

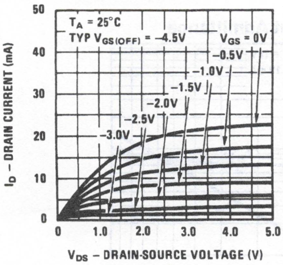
Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−20	−30		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 10V, V_{GS} = 0V$	3	18	40	mA
g_{fs}	Forward Transconductance	$V_{DS} = 10V, V_{GS} = 0V$	5.5	8.0	10	mmhos
g_{fs}	Forward Transconductance	$V_{DS} = 10V, I_D = 5\ mA$	4.5	5.8		mmhos
I_{GSS}	Reverse Gate Current	$V_{GS} = -15V, V_{DS} = 0V$		−5.0	−100	pA
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100\ mV, V_{GS} = 0V$		90		Ω
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 10V, I_D = 1\ nA$	−1.5	−3.5	−6.0	V
g_{os}	Output Conductance	$V_{DG} = 10V, I_D = 5\ mA$		45	100	µmhos
C_{rs}	Feedback Capacitance	$V_{DG} = 10V, I_D = 5\ mA$		1.0	1.2	pF
C_{is}	Input Capacitance	$V_{DG} = 10V, I_D = 5\ mA$		4.0	5.0	pF
e_n	Noise Voltage	$V_{DG} = 10V, I_D = 5\ mA, f = 100\ Hz$		13		$nV/\sqrt{Hz}$
NF	Noise Figure	$V_{DG} = 10V, I_D = 5\ mA, f = 450\ MHz$		3.0		dB
G_{pg} (CG)	Power Gain	$V_{DG} = 10V, I_D = 5\ mA, f = 450\ MHz$		11		dB

This process is available in the following device types. *Denotes preferred parts.

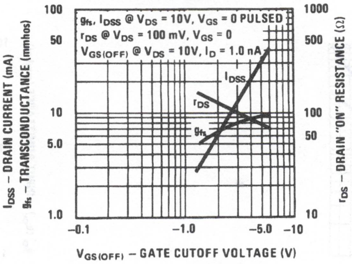
TO-72 (NS Package 29)	TO-92 (NS Package 92)	TO-92 (NS Package 97)
*2N5397	J114	*2N5245
*2N5398	*J210	*2N5246
	*J211	*2N5247
	*J212	
	*J300	
	MPF256	

Process 90

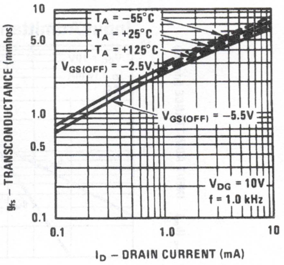
Common Drain-Source Characteristics



Parameter Interactions

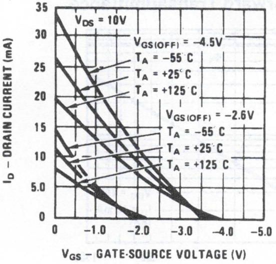


Transconductance vs Drain Current

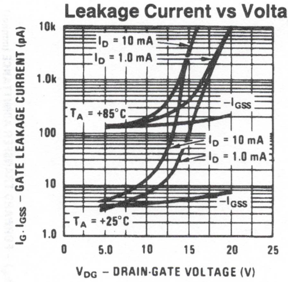


TL/G/10035-29

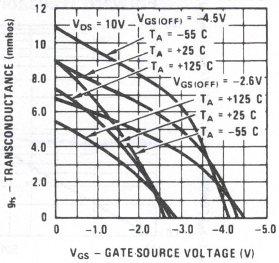
Transfer Characteristics



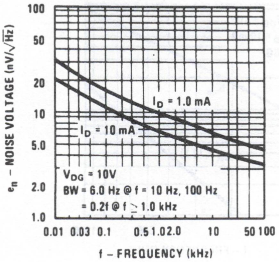
Leakage Current vs Voltage



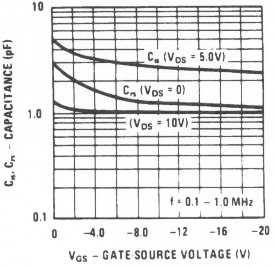
Transfer Characteristics



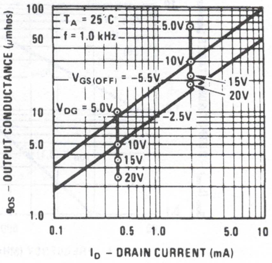
Noise Voltage vs Frequency



Capacitance vs Voltage



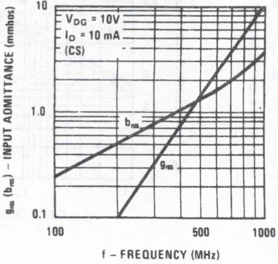
Output Conductance vs Drain Current



TL/G/10035-30

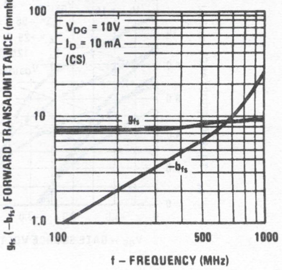
COMMON SOURCE

Input Admittance



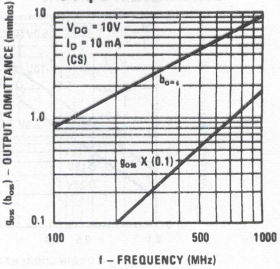
TL/G/10035-31

Forward Transadmittance



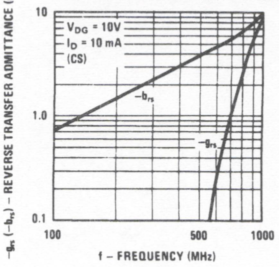
TL/G/10035-33

Output Admittance



TL/G/10035-35

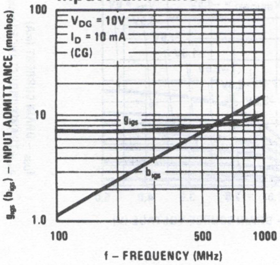
Reverse Transadmittance



TL/G/10035-37

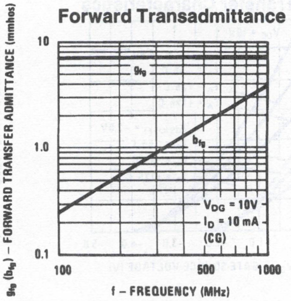
COMMON GATE

Input Admittance



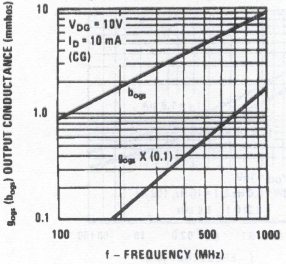
TL/G/10035-32

Forward Transadmittance



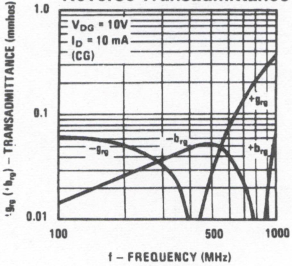
TL/G/10035-34

Output Admittance



TL/G/10035-36

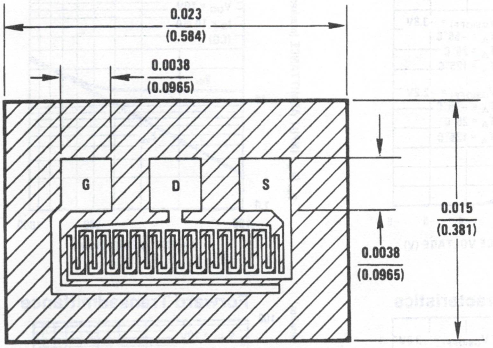
Reverse Transadmittance



TL/G/10035-38

National Semiconductor

Process 92
N-Channel JFET



TL/G/10035-39

Gate is also backside contact

DESCRIPTION

Process 92 is designed for VHF/UHF amplifier, oscillator, and mixer applications. As a common gate amplifier, 16 dB at 100 MHz and 12 dB at 450 MHz can be realized. Worst case 75Ω input impedance provides ideal input match.

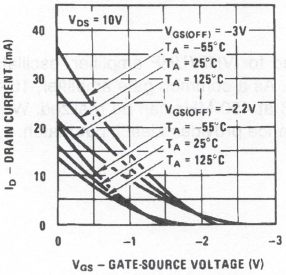
Electrical Characteristics (T_A = 25°C)

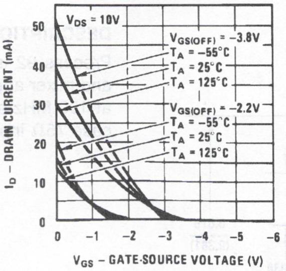
Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	V_{DS} = 0V, I_G = −1 μA	−20	−30		V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 10V, V_{GS} = 0V, Pulsed	10	38	80	mA
g_{fs}	Forward Transconductance	V_{DS} = 10V, V_{GS} = 0V, Pulsed		19		mmhos
g_{fs}	Forward Transconductance	V_{DG} = 10V, I_D = 10 mA	10	13	18	mmhos
I_{GSS}	Reverse Gate Current	V_{GS} = −15V, V_{DS} = 0V		−15	−100	pA
$r_{DS(ON)}$	ON Resistance	V_{DS} = 100 mV, V_{GS} = 0V	35	45	80	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	V_{DS} = 10V, I_D = 1 nA	−1.5	−4.0	−6.5	V
g_{os}	Output Conductance	V_{DG} = 10V, I_D = 10 mA		160	250	μmhos
C_{gd}	Feedback Capacitance	V_{DG} = 10V, I_D = 10 mA, f = 1 MHz		2.0	2.5	pF
C_{gs}	Input Capacitance	V_{DG} = 10V, I_D = 10 mA, f = 1 MHz		4.1	5.0	pF
e_n	Noise Voltage	V_{DG} = 10V, I_D = 10 mA, f = 100 Hz		6.0		nV/√Hz
NF	Noise Figure	V_{DG} = 10V, I_D = 10 mA, f = 450 MHz		3.0		dB
G_{pg}	Power Gain	V_{DG} = 10V, I_D = 10 mA, f = 450 MHz		12		dB

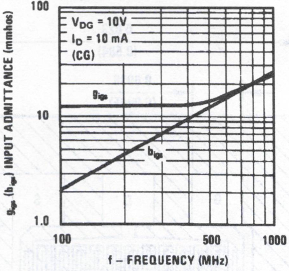
This process is available in the following device types. *Denotes preferred parts.

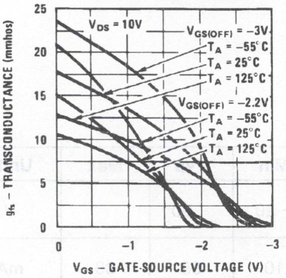
TO-52 (NS Package 07)	TO-92 (NS Package 92)	TO-236/SOT23 (NS Package 48/49)
U308	J308	MMBFJ309
*U309	*J309	MMBFJ310
*U310	*J310	

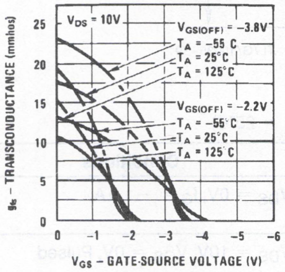
Process 92

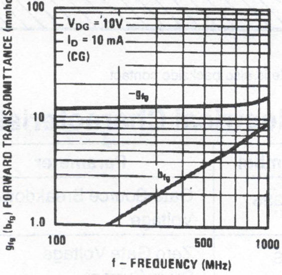

Transfer Characteristics

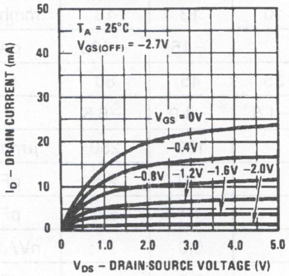

Transfer Characteristics

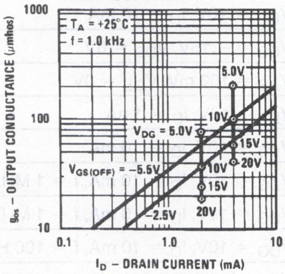

Input Admittance

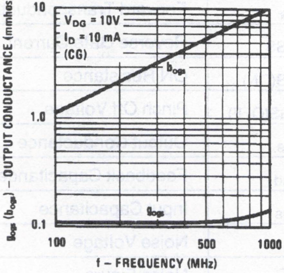

Transfer Characteristics

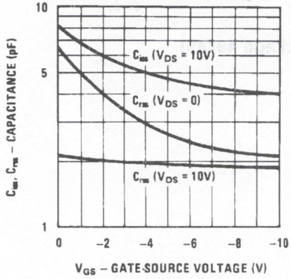

Transfer Characteristics

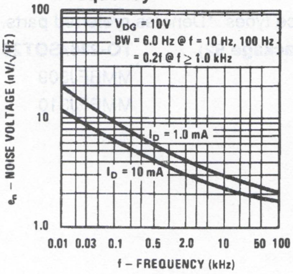

Forward Transadmittance

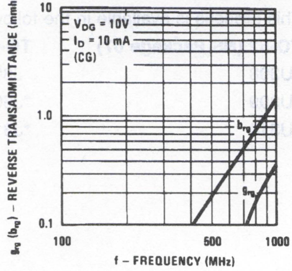

Common Drain-Source Characteristics


Output Conductance vs Drain Current


Output Admittance

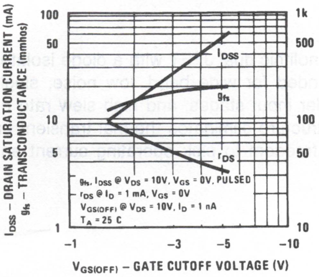

Capacitance vs Voltage


Noise Voltage vs Frequency

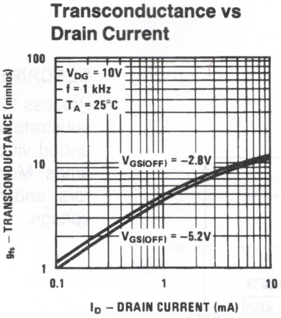

Reverse Transadmittance

TL/G/10035-41

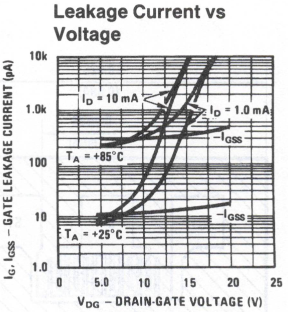
Process 92



Parameter Interactions



Transconductance vs Drain Current

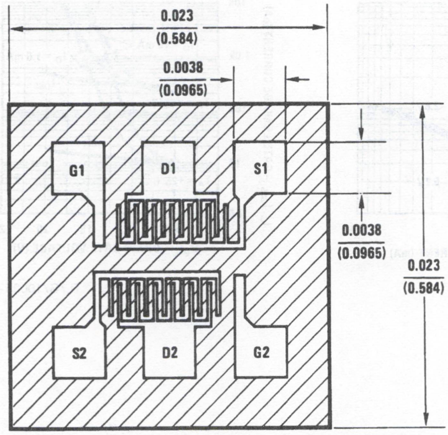


Leakage Current vs Voltage

TL/G/10035-40

National Semiconductor

Process 93
N-Channel Monolithic Dual JFET



TL/G/10035-42

DESCRIPTION

Process 93 is a monolithic dual JFET with a diode isolated substrate. It is intended for wide band, low noise, single ended video amplifier input stages, and high slew rate op amps. Monolithic structure eliminates thermal transient errors, and provides freedom to pick operating current and voltage.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−25	−30		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 10V, V_{GS} = 0V$, Pulsed	3.0	18	40	mA
g_{fs}	Forward Transconductance	$V_{DS} = 10V, V_{GS} = 0V$, Pulsed		8.0		mmhos
g_{fs}	Forward Transconductance	$V_{DG} = 10V, I_D = 5$ mA	5.0	6.0	10	mmhos
g_{os}	Output Conductance	$V_{DG} = 10V, I_D = 5$ mA		50	100	μmhos
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 10V, I_D = 1$ nA	−1.5	−3.5	−6.0	V
$r_{DS(ON)}$	ON Resistance	$V_{DS} = 100$ mV, $V_{GS} = 0V$		100		Ω
I_G	Gate Current	$V_{DG} = 10V, I_D = 5$ mA		10	100	pA
e_n	Noise Voltage	$V_{DG} = 10V, I_D = 5$ mA, f = 100 Hz		9.0	30	$nV/\sqrt{Hz}$
$\lvert V_{GS1}-V_{GS2}\rvert$	Differential Match	$V_{DG} = 10V, I_D = 5$ mA		9.0	30	mV
$\Delta V_{GS1}-V_{GS2}$	Differential Match Drift	$V_{DG} = 10V, I_D = 5$ mA		15	40	μV/°C
CMRR	Common-Mode Rejection	$V_{DG} = 10V, I_D = 5$ mA		90		dB
C_{rs}	Feedback Capacitance	$V_{DG} = 10V, I_D = 5$ mA, f = 1 MHz		1.0	1.2	pF
C_{is}	Input Capacitance	$V_{DG} = 10V, I_D = 5$ mA, f = 1 MHz		4.2	5.0	pF

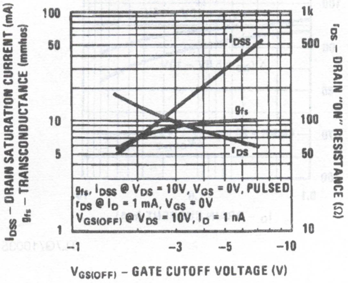
This process is available in the following device types. *Denotes preferred parts.

TO-78 (NS Package 24)	TO-71 (NS Package 12)
*2N5911	NF5911
*2N5912	NF5912
U257	NF5912C
	U440
	U441

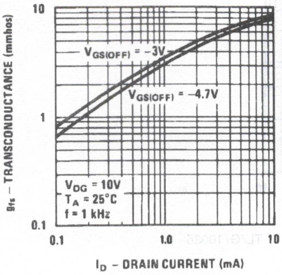
Note: SO-8 to be announced.

Process 93

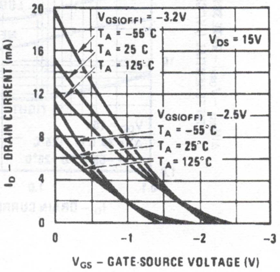
Parameter Interactions



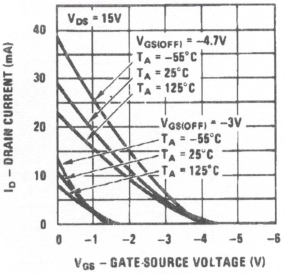
Transconductance vs Drain Current



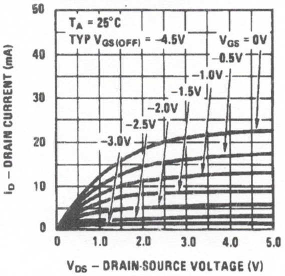
Transfer Characteristics



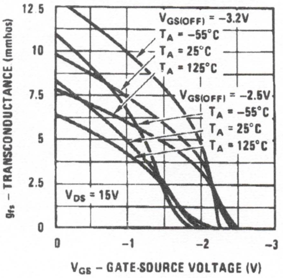
Transfer Characteristics



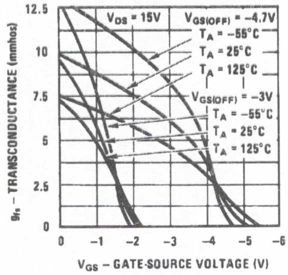
Common Drain-Source Characteristics



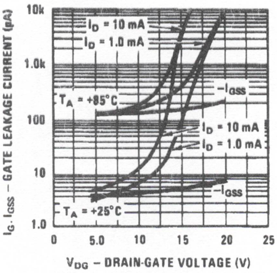
Transfer Characteristics



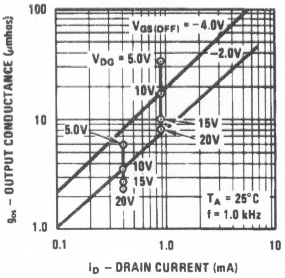
Transfer Characteristics



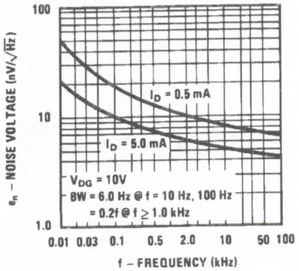
Leakage Current vs Voltage



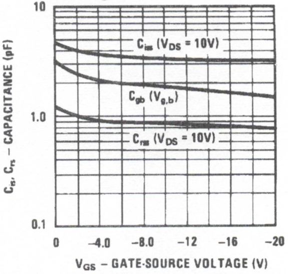
Output Conductance vs Drain Current



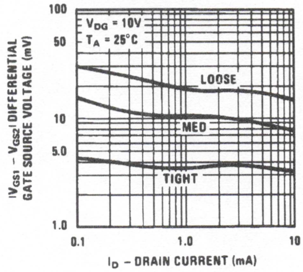
Noise Voltage vs Frequency



Capacitance vs Voltage

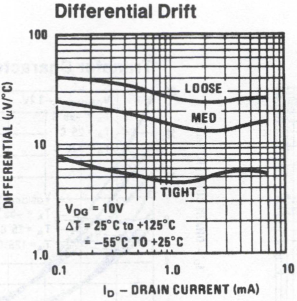


Differential Offset

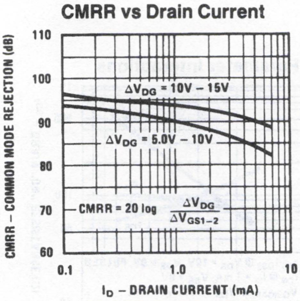


TL/G/10035–43

Process 93



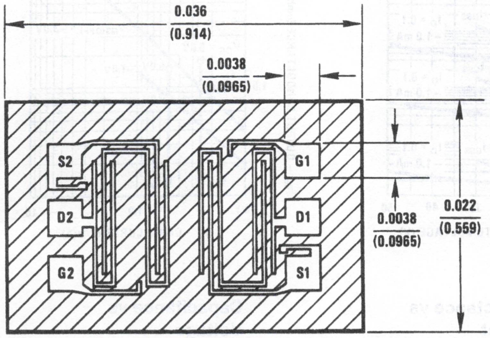
TL/G/10035-44



TL/G/10035-45

National Semiconductor

Process 94
N-Channel Monolithic Dual JFET



TL/G/10035–46

DESCRIPTION

Process 94 is a monolithic dual JFET. It is strictly intended for operational amplifier input buffer applications. Special processing results in extremely low input bias current and virtually unmeasurable offset current. It is important to note that the <5 pA bias current is measured at 35V. Typical CMRR is 125 dB. Performance superior to electrometer tubes can be readily achieved with low offset voltage and almost zero long term drift.

Electrical Characteristics ($T_A = 25^\circ C$)

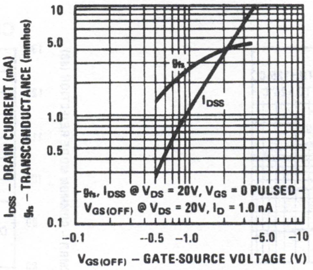
Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−40	−70		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 15V, V_{GS} = 0V$	0.5	3.0	10	mA
g_{fs}	Forward Transconductance	$V_{DS} = 15V, V_{GS} = 0V$	1.5	3.5	7.0	mmho
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 0.2\ mA$	0.7	1.2	1.8	mmhos
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 15V, I_D = 1\ nA$	−0.5	−2.0	−6.0	V
I_G	Gate Current	$V_{DG} = 35V, I_D = 0.20\ mA$		2.0	15	pA
C_{rss}	Feedback Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		0.01	0.02	pF
C_{iss}	Input Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		4.0	5.0	pF
e_n	Noise Voltage	$V_{DG} = 15V, I_D = 0.2\ mA, f = 10\ Hz$		12	50	$nV/\sqrt{Hz}$
g_{os}	Output Conductance	$V_{DG} = 15V, I_D = 0.2\ mA$		<0.1		μmhos
$\lvert V_{GS1}-V_{GS2}\rvert$	Differential Match	$V_{DG} = 15V, I_D = 0.2\ mA$		5.0	25	mV
$\Delta V_{GS1}-V_{GS2}$	Differential Match Drift	$V_{DG} = 15V, I_D = 0.2\ mA$		6.0	50	$\mu V/^\circ C$
CMRR	Common-Mode Rejection	$V_{DG} = 15V, I_D = 0.2\ mA$		125		dB

This process is available in the following device types. *Denotes preferred parts.

TO-71 (NS Package 12)

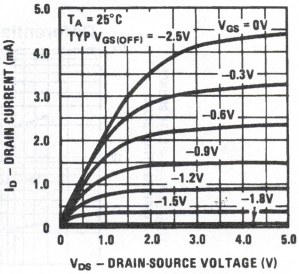
*NDF9406
*NDF9407
*NDF9408
*NDF9409
*NDF9410

Parameter Interactions



TL/G/10035–47

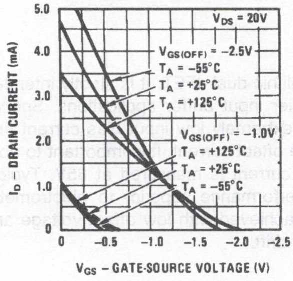
Common Drain-Source Characteristics



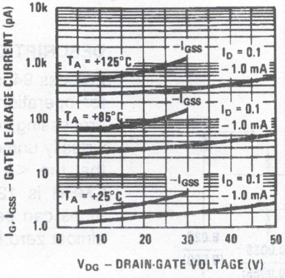
TL/G/10035–48

Process 94

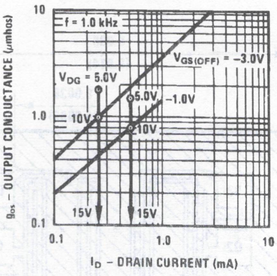
Transfer Characteristics



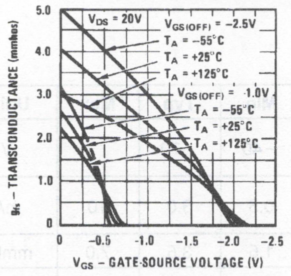
Leakage Current vs Voltage



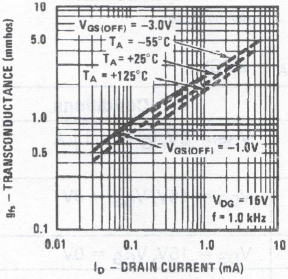
Output Conductance vs Drain Current



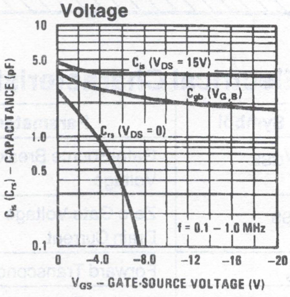
Transfer Characteristics



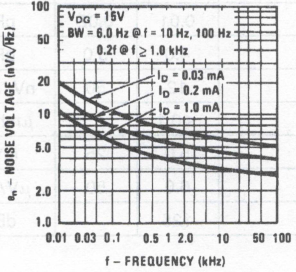
Transconductance vs Drain Current



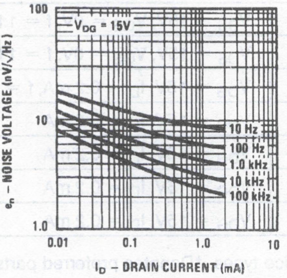
Capacitance vs Voltage



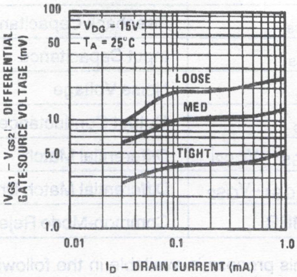
Noise Voltage vs Frequency



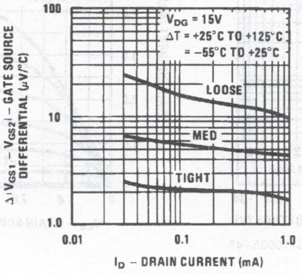
Noise Voltage vs Current



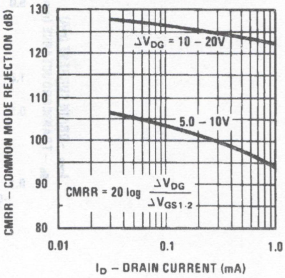
Differential Offset



Differential Drift



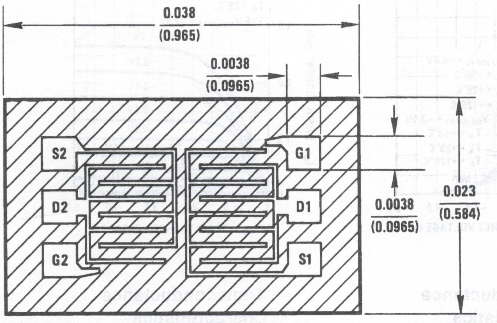
CMRR vs Drain Current



TL/G/10035-49

National Semiconductor

Process 95
N-Channel Monolithic Dual JFET



TL/G/10035-50

DESCRIPTION

Process 95 is a monolithic dual JFET with a diode isolated substrate. It is intended for operational amplifier input buffer applications. Processing results in low input bias current and virtually unmeasurable offset current. Low noise voltage and high CMRR for critical 1/f applications.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	−40	−70		V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 15V, V_{GS} = 0V$	0.5	3.0	8.0	mA
g_{fs}	Forward Transconductance	$V_{DS} = 15V, V_{GS} = 0V$	1.0	2.5	4.0	mmhos
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 0.2\ mA$	0.5	0.7		mmhos
I_{GSS}	Gate Leakage	$V_{GS} = -20V, V_{DS} = 0V$		−5.0	−100	pA
$V_{GS(OFF)}$	Pinch Off Voltage	$V_{DS} = 15V, I_D = 1\ nA$	−0.5	−2.5	−4.0	V
C_{iss}	Input Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		10	14	pF
e_n	Noise Voltage	$V_{DS} = 15V, I_D = 0.2\ mA, f = 10\ Hz$		8.0	30	$nV/\sqrt{Hz}$
e_n	Noise Voltage	$V_{DS} = 15V, I_D = 0.2\ mA, f = 100\ Hz$		6.0	10	$nV/\sqrt{Hz}$
g_{os}	Output Conductance	$V_{DG} = 15V, I_D = 0.2\ mA$		0.3	1.0	μmhos
C_{rss}	Feedback Capacitance	$V_{DS} = 15V, V_{GS} = 0V, f = 1\ MHz$		3.5	5.0	pF
$\|V_{GS1} - V_{GS2}\|$	Differential Match	$V_{DG} = 20V, I_D = 0.2\ mA$		6.0	25	mV
$\Delta V_{GS1} - V_{GS2}$	Differential Match Drift	$V_{DG} = 20V, I_D = 0.2\ mA$		9.0	60	μV/°C
CMRR	Common-Mode Rejection	$V_{DG} = 20V, I_D = 0.2\ mA$	86	115		dB

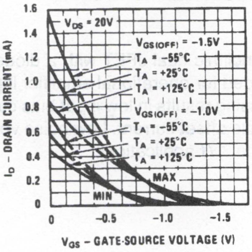
This process is available in the following device types. *Denotes preferred parts.

TO-71 (NS Package 12)

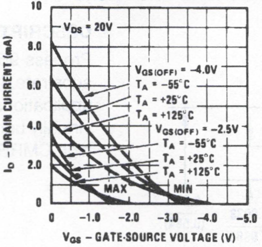
2N5515
2N5516
2N5517
2N5518
2N5519
*2N5520
*2N5521
*2N5522
*2N5523
*2N5524
*2N6483
*2N6484
*2N6485

Process 95

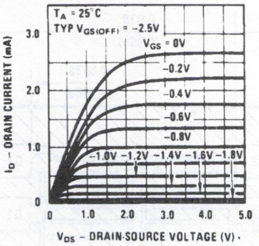
Transfer Characteristics



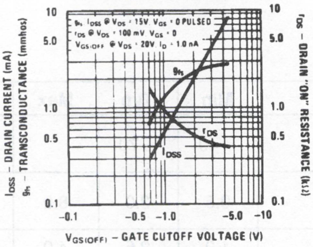
Transfer Characteristics



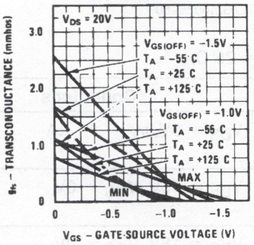
Common Drain-Source Characteristics



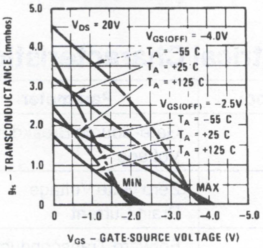
Parameter Interactions



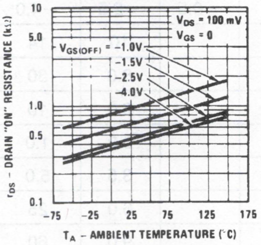
Transconductance Characteristics



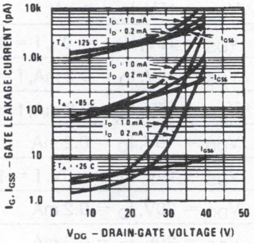
Transconductance Characteristics



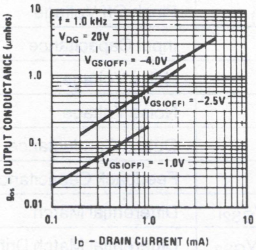
Channel Resistance vs Temperature



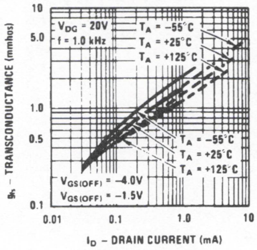
Leakage Current vs Voltage



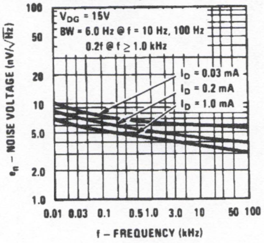
Output Conductance vs Drain Current



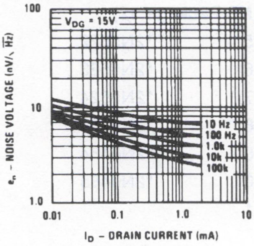
Transconductance vs Drain Current



Noise Voltage vs Frequency

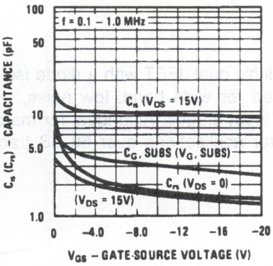


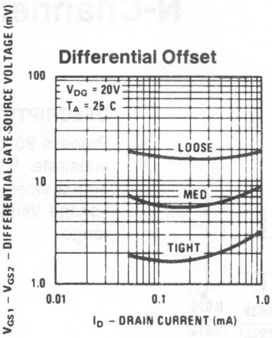
Noise Voltage vs Current

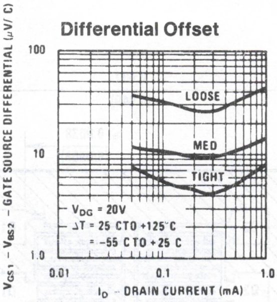


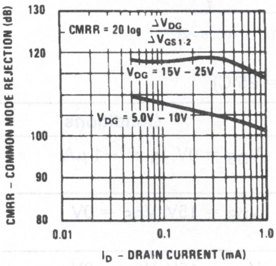
TL/G/10035–51

Process 95


Capacitance vs Voltage


Differential Offset

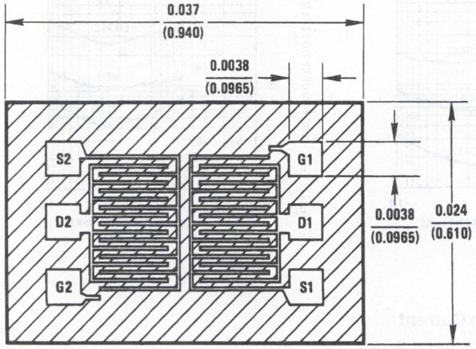

Differential Offset


CMRR vs Drain Current

TL/G/10035-52

National Semiconductor

Process 96
N-Channel Monolithic Dual JFET



TL/G/10035-53

DESCRIPTION

Process 96 is a monolithic dual JFET with a diode isolated substrate. It is intended for wide band, low noise, single ended video amplifier input stages. Also ideal for matched voltage variable resistor applications over 60 dB tracking range.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	V_{DS} = 0V, I_G = −1 μA	−40	−55		V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 15V, V_{GS} = 0V	5.0	15	30	mA
g_{fs}	Forward Transconductance	V_{DS} = 15V, V_{GS} = 0V	9.0	18	30	mmhos
g_{fs}	Forward Transconductance	V_{DG} = 15V, I_D = 2 mA	7.5	9.0		mmhos
g_{os}	Output Conductance	V_{DG} = 15V, I_D = 2 mA		15	45	μmhos
$V_{GS(OFF)}$	Pinch Off Voltage	V_{DS} = 15V, I_D = 1 nA	−0.5	−1.8	−3.0	V
$r_{DS(ON)}$	ON Resistance	V_{DS} = 100 mV, V_{GS} = 0V	35	70	120	Ω
I_{GSS}	Gate Current	V_{GS} = −20V, V_{DS} = 0V		−8.0	−100	pA
I_G	Gate Current	V_{DG} = 15V, I_D = 2 mA		15	200	pA
e_n	Noise Voltage	V_{DG} = 15V, I_D = 2 mA, f = 100 Hz		4.5	10	$\mathrm{nV}/\sqrt{\mathrm{Hz}}$
C_{rs}	Feedback Capacitance	V_{DG} = 15V, I_D = 2 mA, f = 1 MHz		2.5	3.0	pF
C_{is}	Input Capacitance	V_{DG} = 15V, I_D = 2 mA, f = 1 MHz		10	12	pF
$\lvert V_{GS1}-V_{GS2}\rvert$	Differential Voltage	V_{DG} = 15V, I_D = 2 mA		8.0	25	mV
$\Delta V_{GS1}-V_{GS2}$	Differential Voltage Drift	V_{DG} = 15V, I_D = 2 mA		9.0	50	μV/°C
CMRR	Common-Mode Rejection	V_{DG} = 15V, I_D = 2 mA	76	95		dB

This process is available in the following device types. *Denotes preferred parts.

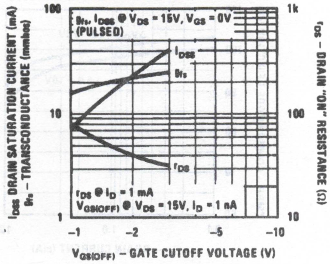
TO-71 (NS Package 12)	**8-Pin DIP (NS Package 67)**
*2N5564	*NPD5564
*2N5565	*NPD5565
*2N5566	*NPD5566

Pin	67
1	S1
2	D1
3	NC
4	G1
5	S2
6	D2
7	NC
8	G2

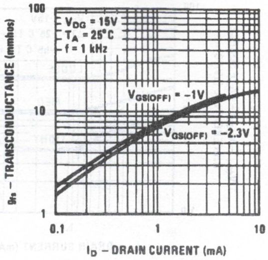
Note: SO-8 to be announced.

Process 96

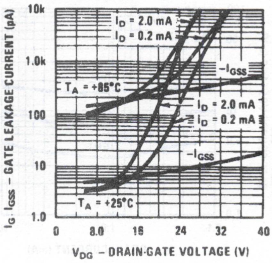
Parameter Interactions



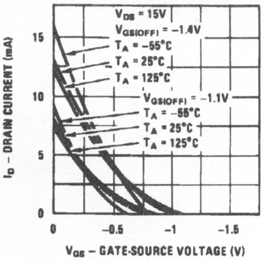
Transconductance vs Drain Current



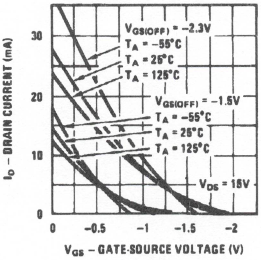
Leakage Current vs Voltage



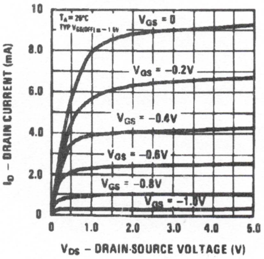
Transfer Characteristics



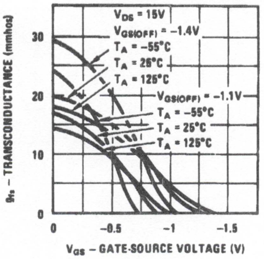
Transfer Characteristics



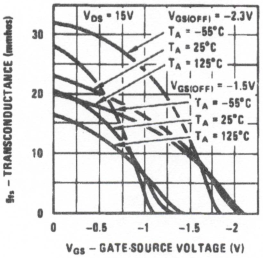
Common Drain-Source Characteristics



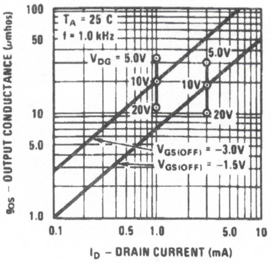
Transfer Characteristics



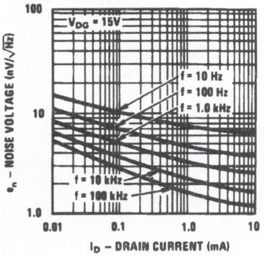
Transfer Characteristics



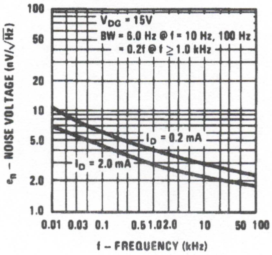
Output Conductance vs Drain Current



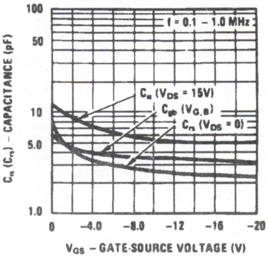
Noise Voltage vs Current



Noise Voltage vs Frequency

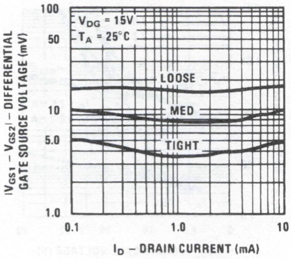


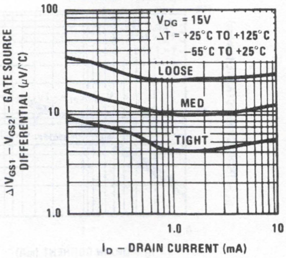
Capacitance vs Voltage

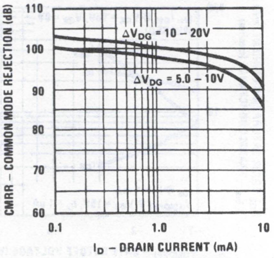


TL/G/10035-54

Process 96


Differential Offset

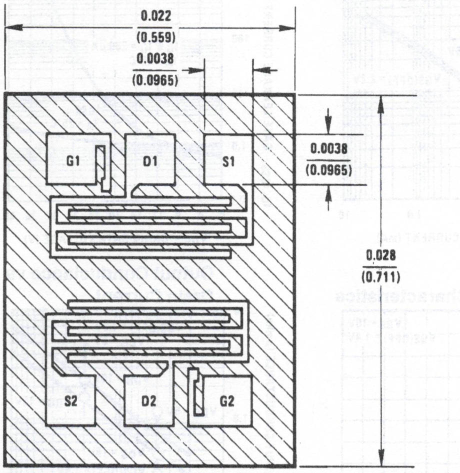

Differential Drift


CMRR vs Drain Current

TL/G/10035-55

National Semiconductor

Process 98
N-Channel JFET



TL/G/10035-56

DESCRIPTION

Process 98 is a high gain, general purpose, monolithic dual JFET with a diode isolated substrate. It is intended for amplifier input stages requiring high gain, low noise and low offset drift over temperature. Strict processing controls result in low input bias currents and virtually immeasurable offset currents. Matching characteristics are essentially independent of operating current and voltage.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Breakdown Voltage	$V_{DS} = 0V, I_G = -1\ \mu A$	50	75		V
I_{GSS}	Gate Leakage Current	$V_{GS} = -30V, V_{DS} = 0V$		2.0	100	pA
$V_{GS(OFF)}$	Pinch-off Voltage	$V_{DS} = 15V, I_D = 1\ nA$	0.5	1.3	3.0	V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 10V, V_{GS} = 0V$	0.5	1.8	10	mA
g_{fs}	Forward Transconductance	$V_{DS} = 10V, V_{GS} = 0V$	2.0	4.5	7.0	mmhos
g_{os}	Output Conductance	$V_{DS} = 10V, V_{GS} = 0V$		8.0	20	μmhos
g_{fs}	Forward Transconductance	$V_{DG} = 15V, I_D = 200\ \mu A$	1.0	1.4	1.8	mmhos
g_{os}	Output Conductance	$V_{DG} = 15V, I_D = 200\ \mu A$		1.3	2.0	μmhos
$\lvert V_{GS1}-V_{GS2}\rvert$	Differential Offset Voltage	$V_{DG} = 10V, I_D = 200\ \mu A$		10	40	mV
C_{rss}	Feedback Capacitance	$V_{DG} = 15V, I_D = 200\ \mu A, f = 1\ MHz$		1.7	3.0	pF
C_{iss}	Input Capacitance	$V_{DG} = 15V, I_D = 200\ \mu A, f = 1\ MHz$		6.0	8.0	pF
e_n	Noise Voltage	$V_{DS} = 15V, I_D = 200\ \mu A, f = 10\ Hz$		8.0	50	$nV/\sqrt{Hz}$
CMRR	Common-Mode Rejection Ratio	$V_{DG} = 5V - 10V, I_D = 200\ \mu A$	90	108		dB

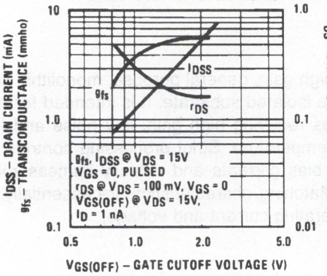
This process is available in the following device types. *Denotes preferred parts.

TO-71 (NS Package 12)		**8-Pin DIP (NS Package 60)**
2N5561	U402	J401
2N5562	U403	J402
2N5563	U404	J403
2N3921	U405	J404
2N3922	U406	J405
U401		J406

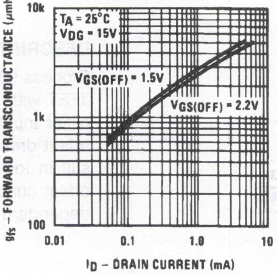
Pin	60
1	NC
2	S1
3	D1
4	G1
5	S2
6	D2
7	G2
8	NC

Process 98

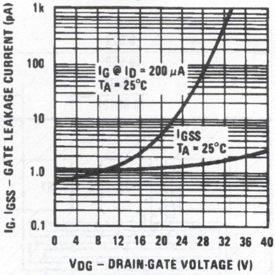
Parameter Interactions



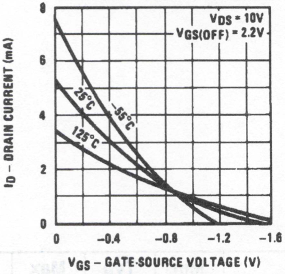
Forward Transconductance vs Drain Current



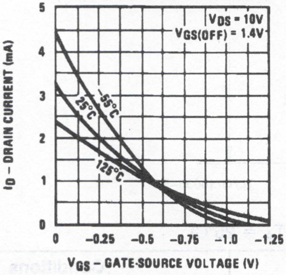
Gate Leakage Current vs Voltage



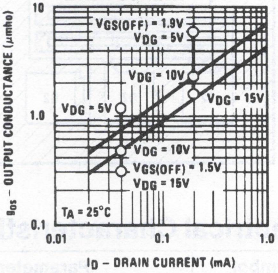
Transfer Characteristics



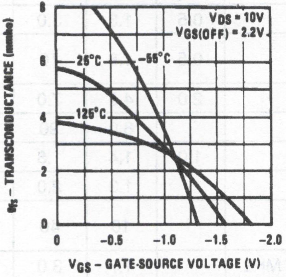
Transfer Characteristics



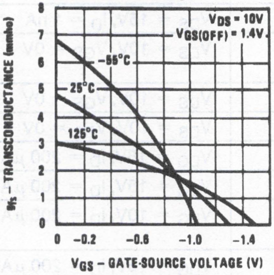
Output Conductance vs Drain Current



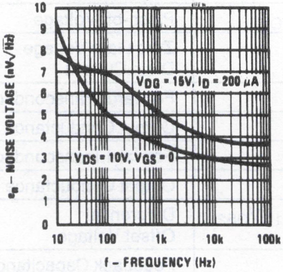
Transconductance vs Gate Source Voltage



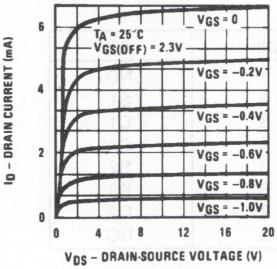
Transconductance vs Gate Source Voltage



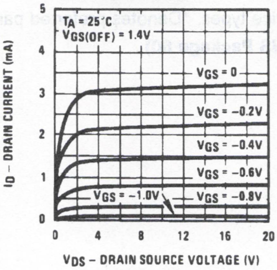
Noise Voltage vs Frequency



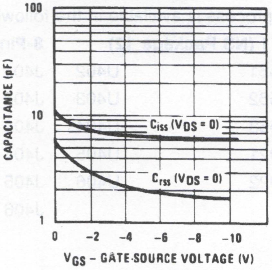
Common Drain Source Characteristics



Common Drain Source Characteristics

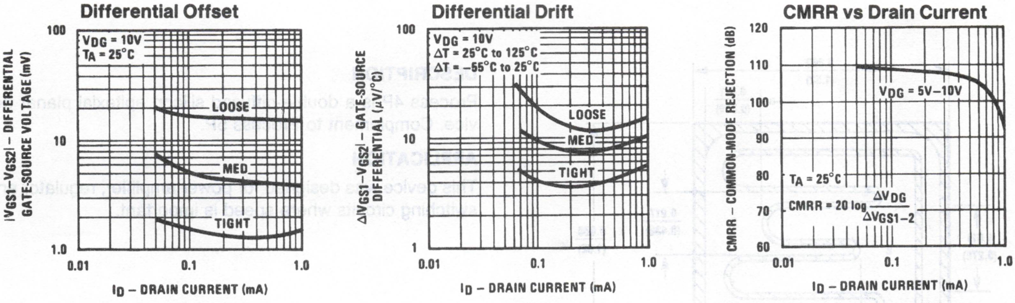


Capacitance vs Gate Source Voltage



TL/G/10035-57

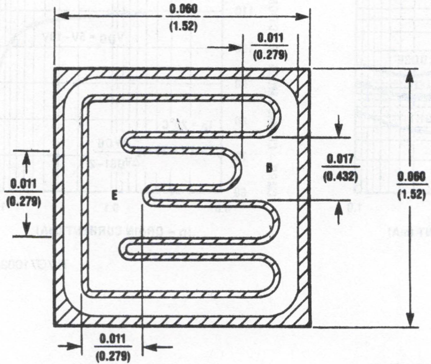
Process 98



TL/G/10035–58

National Semiconductor

Process 4P
NPN Planar Power



TL/G/10036-1

DESCRIPTION

Process 4P is a double-diffused silicon epitaxial planar device. Complement to Process 5P.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

Electrical Characteristics (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	I_C = 100 mA (Note 1)	50		120	V
BV_{CES}	I_C = 1 mA	75			V
BV_{EBO}	I_E = 1 mA	5	8		V
I_{CES}	V_{CE} = 50V			5	μA
I_{EBO}	V_{EB} = 5V			5	μA
h_{FE}	I_C = 20 mA, V_{CE} = 1V	30			
h_{FE}	I_C = 300 mA, V_{CE} = 1V	40	80	300	
h_{FE}	I_C = 4A, V_{CE} = 1V	10			
$V_{CE(SAT)}$	I_C = 2A, I_B = 0.2A		0.5	0.5	V
$V_{BE(SAT)}$	I_C = 2A, I_B = 0.2A		1	1.1	V
f_t	V_{CE} = 5V, I_C = 0.5A	50			MHz
C_{OB}	V_{CB} = 10V		45		pF
C_{IB}	V_{EB} = 1V		400		pF
t_r	I_C = 2A, V_{CE} = 30V I_{B1} = I_{B2} = 0.2A		60		ns
t_s			750		ns
t_f			80		ns
$P_{D(max)}$					
TO-220	T_C = 25°C	40			W
TO-202	T_C = 25°C	15			W
θ_{JC}					
TO-220	T_C = 25°C			3.2	°C/W
TO-202	T_C = 25°C			8.33	°C/W
θ_{JA}					
TO-220	T_A = 25°C			62.5	°C/W
TO-202	T_A = 25°C			62.5	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

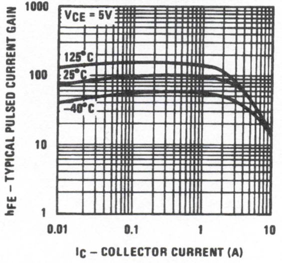
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4P

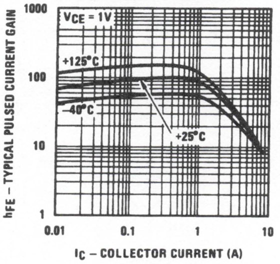
This process is available in the following device types.

	V_{CEO} (V), Min	h_{FE} Min	h_{FE} Max	@ I_C (A)
TO-202 (NS Package 56)				
D42C1	30	25		0.2
D42C2	30	40	120	0.2
D42C3	30	40		0.2
D42C4	45	25		0.2
D42C5	45	40	120	0.2
D42C6	45	40		0.2
D42C7	60	25		0.2
D42C8	60	40	120	0.2
D42C9	60	40		0.2
D42C10	80	25		0.2
D42C11	80	40	120	0.2
D42C12	80	40		0.2
TO-220 (NS Package 57)				
D44C1	30	25		0.2
D44C2	30	40	120	0.2
D44C3	30	40		0.2
D44C4	45	25		0.2
D44C5	45	40	120	0.2
D44C6	45	40		0.2
D44C7	60	25		0.2
D44C8	60	40	120	0.2
D44C9	60	40		0.2
D44C10	80	25		0.2
D44C11	80	40	120	0.2
D44C12	80	40		0.2

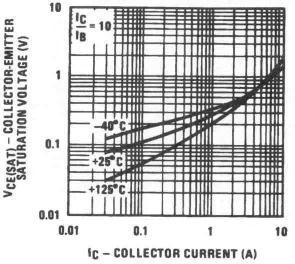
Typical Pulsed Current Gain vs Collector Current



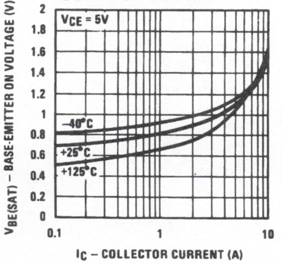
Typical Pulsed Current Gain vs Collector Current



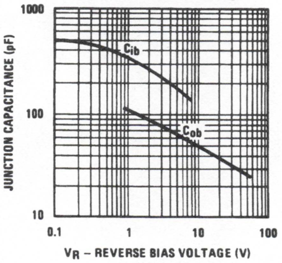
Collector-Emitter Saturation Voltage vs Collector Current



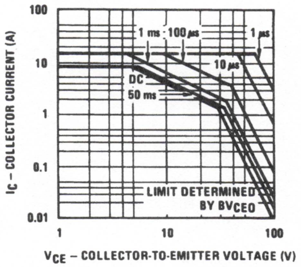
Base-Emitter ON Voltage vs Collector Current



Junction Capacitance vs Reverse Bias Voltage



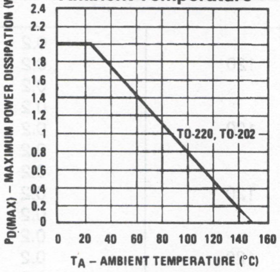
Safe Operating Area TO-220



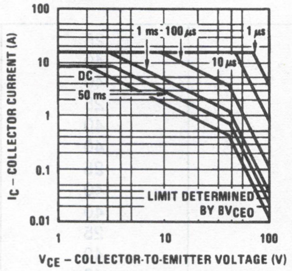
TL/G/10036–2

Process 4P

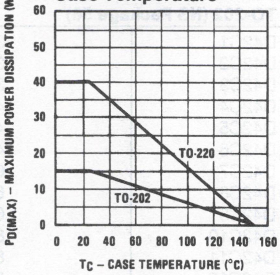
Minimum Power Dissipation vs Ambient Temperature



Safe Operating Area TO-202

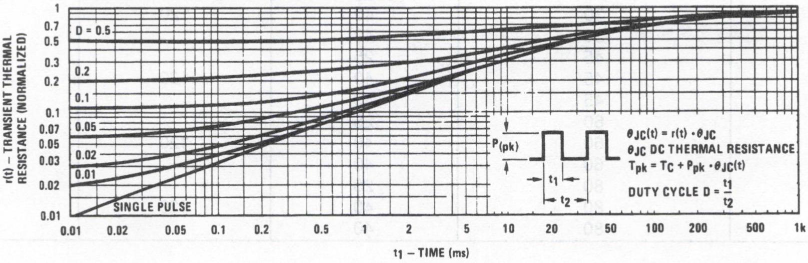


Maximum Power Dissipation vs Case Temperature



TL/G/10036-3

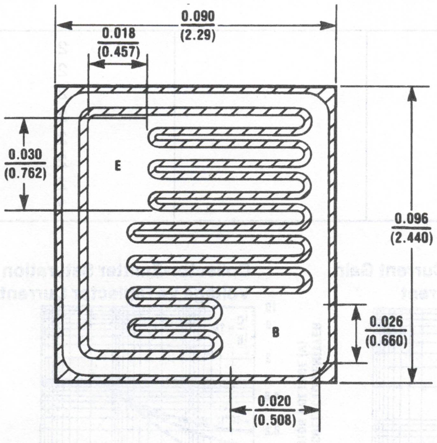
Thermal Response in TO-220 Package



TL/G/10036-4

National Semiconductor

Process 4Q
NPN Planar Power



TL/G/10036-6

DESCRIPTION

Process 4Q is a double-diffused silicon epitaxial planar device. Complement to Process 5Q.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

Electrical Characteristics (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	I_C = 100 mA (Note 1)	50		120	V
BV_{CES}	I_C = 1 mA	75			V
BV_{EBO}	I_E = 1 mA	5	8		V
I_{CES}	V_{CE} = 50V			5	μA
I_{EBO}	V_{EB} = 5V			5	μA
h_{FE}	I_C = 30 mA, V_{CE} = 1V	30			
h_{FE}	I_C = 0.5A, V_{CE} = 1V	40		300	
h_{FE}	I_C = 8A, V_{CE} = 1V	10			
$V_{CE(SAT)}$	I_C = 4A, I_B = 0.4A			0.5	V
$V_{BE(SAT)}$	I_C = 4A, I_B = 0.4A			1.1	V
f_t	V_{CE} = 5V, I_C = 0.5A	50			MHz
C_{OB}	V_{CB} = 10V		110		pF
C_{IB}	V_{EB} = 1V		730		pF
t_r	I_C = 5A, V_{CE} = 30V I_{B1} = I_{B2} = 0.5A		30		ns
t_s			500		ns
t_f			60		ns
$P_{D(max)}$ TO-220	T_C = 25°C	60			W
θ_{JC} TO-220	T_C = 25°C			2.08	°C/W
θ_{JA} TO-220	T_A = 25°C			62.5	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

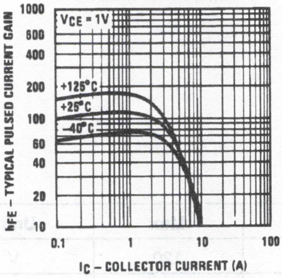
Note 1: Pulsed measurement = 300 μs pulse width.

Process 4Q

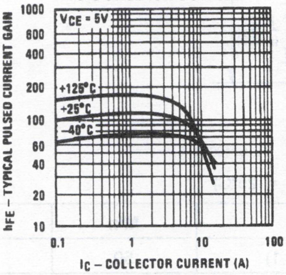
This process is available in the following device types.

	V_{CEO} (V), Min	h_{FE}		@ I_C (A)
		Min	Max	
TO-220 (NS Package 57)				
D44H1	30	35		2
D44H2	30	60		2
D44H4	45	35		2
D44H5	45	60		2
D44H7	60	35		2
D44H8	60	60		2
D44H10	80	35		2
D44H11	80	60		2

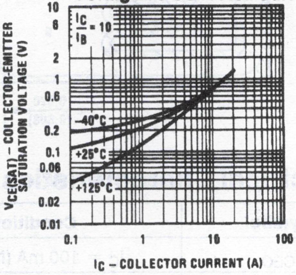
Typical Pulsed Current Gain vs Collector Current



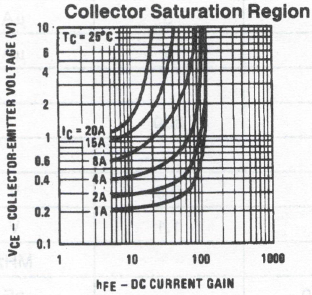
Typical Pulsed Current Gain vs Collector Current



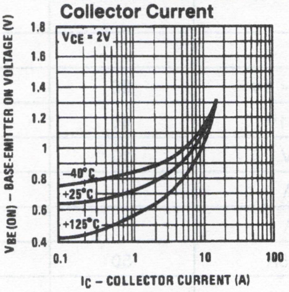
Collector-Emitter Saturation Voltage vs Collector Current



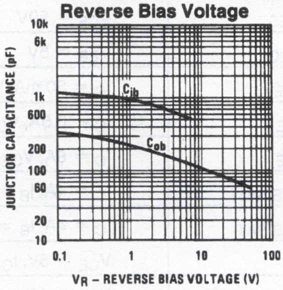
Collector Saturation Region



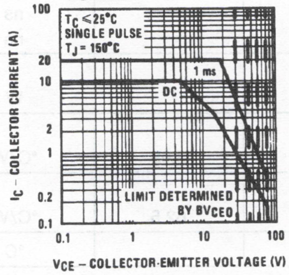
Base-Emitter ON Voltage vs Collector Current



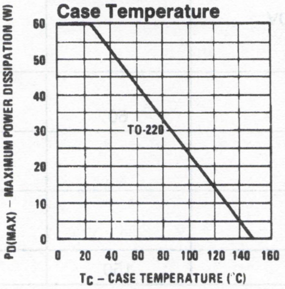
Junction Capacitance vs Reverse Bias Voltage



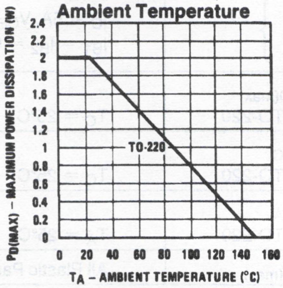
Safe Operating Area TO-220



Maximum Power Dissipation vs Case Temperature



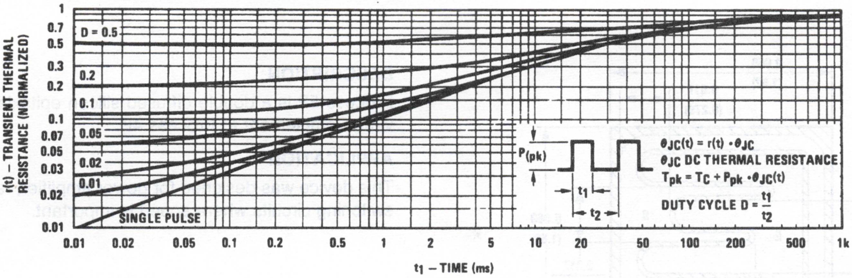
Maximum Power Dissipation vs Ambient Temperature



TL/G/10036-7

Process 4Q

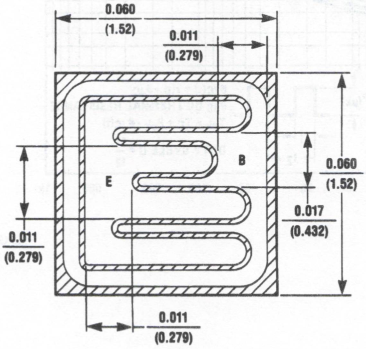
Thermal Response in TO-220 Package



TL/G/10036–8

National Semiconductor

Process 5P
PNP Planar Power



TL/G/10036-9

DESCRIPTION

Process 5P is a double diffused silicon epitaxial planar device. Complement to Process 4P.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

Electrical Characteristics ($T_A = 25°C$)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	$I_C = 100$ mA (Note 1)	50		120	V
BV_{CES}	$I_C = 1$ mA				V
BV_{EBO}	$I_E = 1$ mA	5	8		V
I_{CES}	$V_{CE} = 50V$			5	μA
I_{EBO}	$V_{EB} = 5V$			5	μA
h_{FE}	$V_{CE} = 5V, I_C = 20$ mA	30			
h_{FE}	$V_{CE} = 5V, I_C = 0.5A$	50	80	200	
h_{FE}	$V_{CE} = 5V, I_C = 5A$ (Note 1)	10			
$V_{CE(SAT)}$	$I_C = 3A, I_B = 0.3A$		0.35	1	V
$V_{BE(SAT)}$	$I_C = 3A, I_B = 0.3A$		1.1		V
f_t	$V_{CE} = 5V, I_C = 0.5A$	40			MHz
C_{OB}	$V_{CB} = 10V$		75		pF
C_{IB}	$V_{EB} = 1V$		400		pF
t_r t_s t_f	$I_C = 2A, V_{CE} = 30V$ $I_{B1} = I_{B2} = 0.2A$		60 500 50		ns ns ns
$P_{D(max)}$					
TO-220	$T_C = 25°C$	40			W
TO-202	$T_C = 25°C$	15			W
θ_{JC}					
TO-220	$T_C = 25°C$			3.2	°C/W
TO-202	$T_C = 25°C$			8.33	°C/W
θ_{JA}					
TO-220	$T_A = 25°C$			62.5	°C/W
TO-202	$T_A = 25°C$			62.5	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

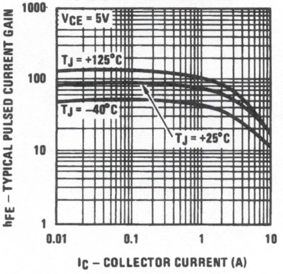
Note 1: Pulsed measurement = 300 μs pulse width.

Process 5P

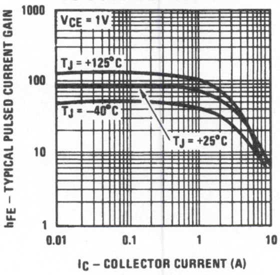
This process is available in the following device types.

	V_{CEO} (V), Min	h_{FE} Min	h_{FE} Max	@ I_C (A)
TO-202 (NS Package 56)				
D43C1	30	25		0.2
D43C2	30	40	120	0.2
D43C3	30	40		0.2
D43C4	45	25		0.2
D43C5	45	40	120	0.2
D43C6	45	40		0.2
D43C7	60	25		0.2
D43C8	60	40	120	0.2
D43C9	60	40		0.2
D43C10	80	25		0.2
D43C11	80	40	120	0.2
D43C12	80	40		0.2
TO-220 (NS Package 57)				
D45C1	30	25		0.2
D45C2	30	40	120	0.2
D45C3	30	40		0.2
D45C4	45	25		0.2
D45C5	45	40	120	0.2
D45C6	45	40		0.2
D45C7	60	25		0.2
D45C8	60	40	120	0.2
D45C9	60	40		0.2
D45C10	80	25		0.2
D45C11	80	40	120	0.2
D45C12	80	40		0.2

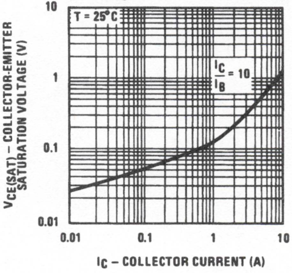
Typical Pulsed Current Gain vs Collector Current



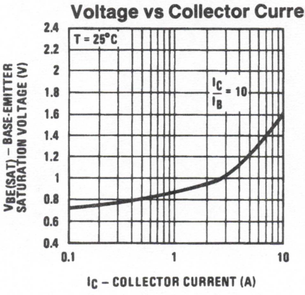
Typical Pulsed Current Gain vs Collector Current



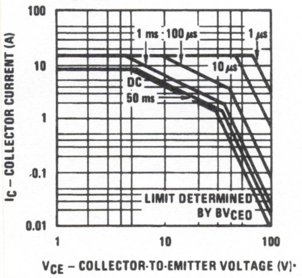
Collector-Emitter Saturation Voltage vs Collector Current



Base-Emitter Saturation Voltage vs Collector Current

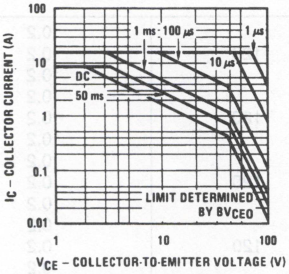


Safe Operating Area TO-220

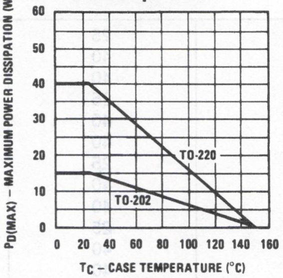


TL/G/10036–10

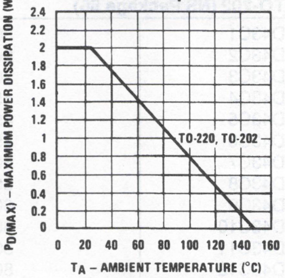
Safe Operating Area TO-202



Maximum Power Dissipation vs Case Temperature

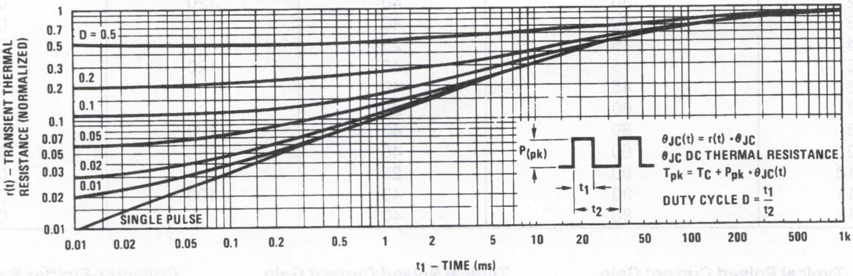


Maximum Power Dissipation vs Ambient Temperature



TL/G/10036–11

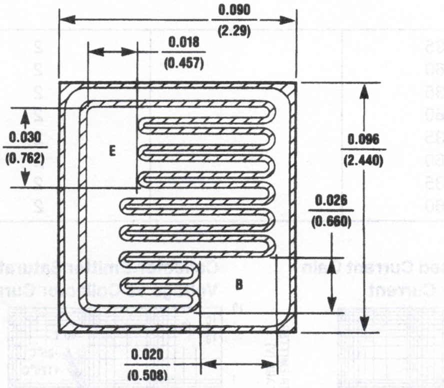
Thermal Response in TO-220 Package



TL/G/10036–12

National Semiconductor

Process 5Q
PNP Planar Power



TL/G/10036-14

DESCRIPTION

Process 5Q is a double-diffused silicon epitaxial planar device. Complement to Process 4Q.

APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

Electrical Characteristics (T_A = 25°C)

Symbol	Conditions	Min	Typ	Max	Units
BV_{CEO}	I_C = 100 mA (Note 1)	50		120	V
BV_{CES}	I_C = 1 mA	60			V
BV_{EBO}	I_E = 1 mA	5	8		V
I_{CES}	V_{CE} = 50V			5	µA
I_{EBO}	V_{EB} = 5V			5	µA
h_{FE}	V_{CE} = 5V, I_C = 20 mA	30			
h_{FE}	V_{CE} = 5V, I_C = 1A (Note 1)	50	100	300	
h_{FE}	V_{CE} = 5V, I_C = 8A (Note 1)	20			
$V_{CE(SAT)}$	I_C = 8A, I_B = 0.8A (Note 1)		0.6	1	V
$V_{BE(SAT)}$	I_C = 8A, I_B = 0.8A (Note 1)		1.2		V
f_t	V_{CE} = 5V, I_C = 0.5A	40			MHz
C_{OB}	V_{CB} = 10V		170		pF
C_{IB}	V_{EB} = 1V		870		pF
t_r t_s t_f	I_C = 5A, V_{CE} = 30V I_{B1} = I_{B2} = 0.5A		40 500 60		ns ns ns
$P_{D(max)}$ TO-220	T_C = 25°C	60			W
θ_{JC} TO-220	T_C = 25°C			2.08	°C/W
θ_{JA} TO-220	T_A = 25°C			62.5	°C/W
$T_{J(max)}$	All Plastic Parts	150			°C

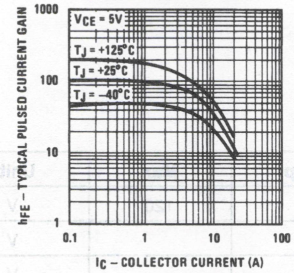
Note 1: Pulsed measurement = 300 µs pulse width.

Process 5Q

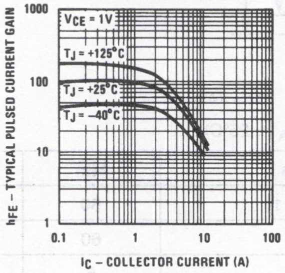
This process is available in the following device types.

	V_{CEO} (V), Min	h_{FE}		@ I_C (A)
		Min	Max	
TO-220 (NS Package 57)				
D45H1	30	35		2
D45H2	30	60		2
D45H4	45	35		2
D45H5	45	60		2
D45H7	60	35		2
D45H8	60	60		2
D45H10	80	35		2
D45H11	80	60		2

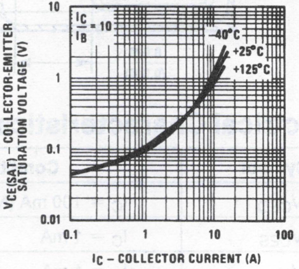
Typical Pulsed Current Gain vs Collector Current



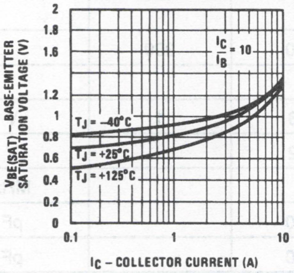
Typical Pulsed Current Gain vs Collector Current



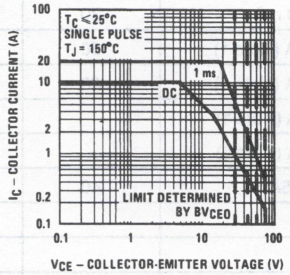
Collector-Emitter Saturation Voltage vs Collector Current



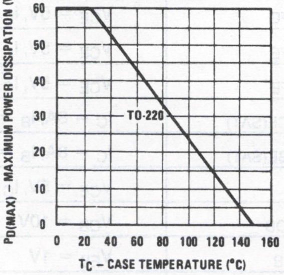
Base-Emitter Saturation Voltage vs Collector Current



Safe Operating Area TO-220

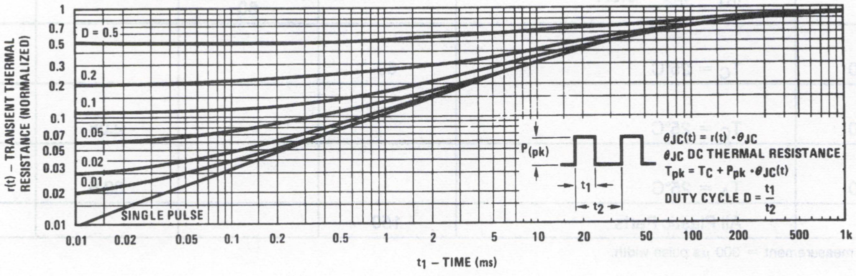


Maximum Power Dissipation vs Case Temperature



TL/G/10036–15

Thermal Response in TO-220 Package

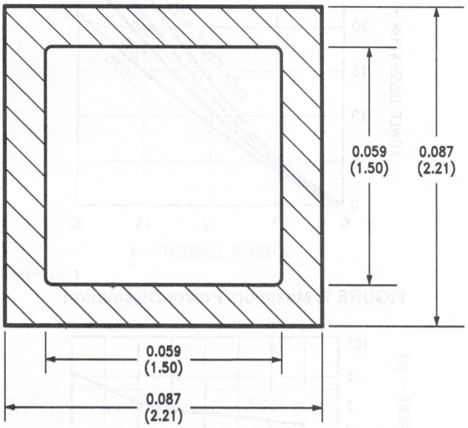


TL/G/10036–16

National Semiconductor

Process R4
Ultra-Fast Rectifier

RO72



TL/G/10039-1

Note 1: Dimension Tolerances ±0.0005 in. (0.013mm).
Note 2: Thickness of all die types is 0.010 in. (250 µ).

DESCRIPTION

These dice are designed especially for use in switching power supplies, inverters and PWM motor controls. These dice feature low reverse recovery current with soft recovery.

Electrical Characteristics

Symbol	Parameter	Conditions	Min	Max	Units
V_{RRM}	Peak Repetitive Reverse Voltage (Note 1)	$I_R = 0.5$ mA	200		V
I_{RRM}	Maximum Instantaneous Reverse Current (Note 1)	$V_R = V_{RRM}$ $T_J = 125°C$ $T_J = 25°C$		 5 10	 mA µA
V_{FM}	Maximum Instantaneous Forward Voltage	$I_F = 8.0A$	0.95		V
$I_{R\ (rec)}$	Maximum Reverse Recovery Current (Note 2)	$I_F = 8.0A; V_R = V_{RRM}$ $dI_F/dt = 100A/\mu s$		2.5	A
t_{RR}	Maximum Reverse Recovery Time	$I_F = 1A; dI_F/dt = 50A/\mu s$ $I_F = 8A; dI_F/dt = 100A/\mu s$		35 50	ns ns

Note 1: Pulse Test: Pulse Width = 300 µs. Duty Cycle ≤ 2.0%.
Note 2: See *Figure 10* for test conditions.

This process is available in the following device types:

TO-220AB (Case 38)

FRP1605CC	FRP2005CC
FRP1610CC	FRP2010CC
FRP1615CC	FRP2015CC
FRP1620CC	FRP2020CC

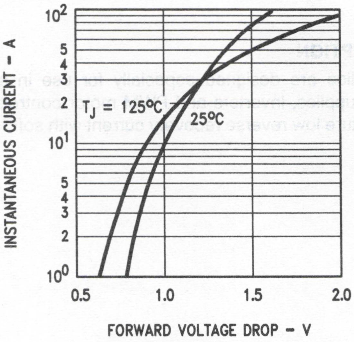
TO-220AC (Case 41)

FRP805	FRP1005
FRP810	FRP1010
FRP815	FRP1015
FRP820	FRP1020

FRP #	805	810	815	820	1005	1010	1015	1020	Unit
V_{RRM} ($I_R = 0.5$ mA)	50	100	150	200	50	100	150	200	V
FRP #	**1605CC**	**1610CC**	**1615CC**	**1620CC**	**2005CC**	**2010CC**	**20150CC**	**2020CC**	**Unit**
V_{RRM} ($I_R = 0.5$ mA)	50	100	150	200	50	100	150	200	V

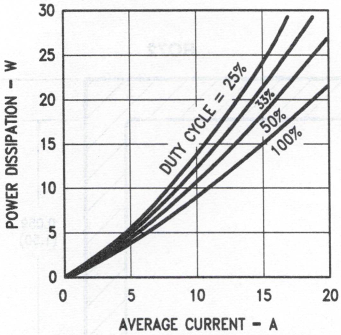
Process R4

Performance Characteristics



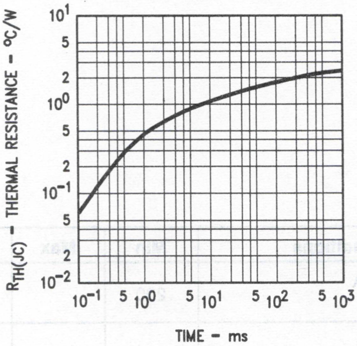
TL/G/10039-2

FIGURE 1. Maximum Forward Voltage Drop



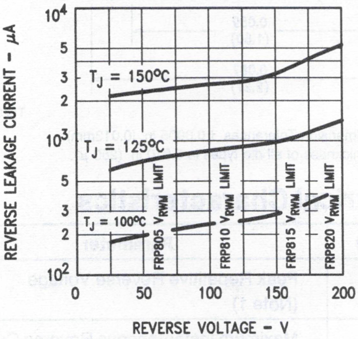
TL/G/10039-3

FIGURE 2. Maximum Power Dissipation



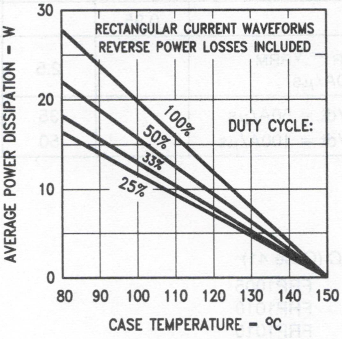
TL/G/10039-4

FIGURE 3. Maximum Transient Thermal Resistance



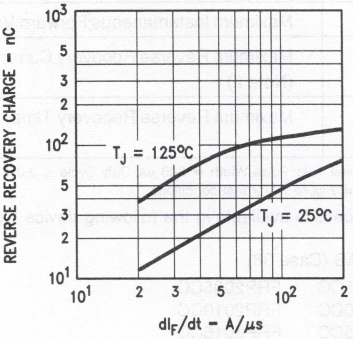
TL/G/10039-5

FIGURE 4. Typical Reverse Leakage Current



TL/G/10039-6

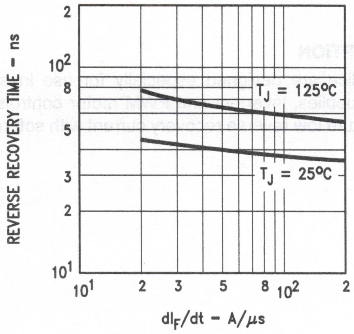
FIGURE 5. Power Derating



TL/G/10039-7

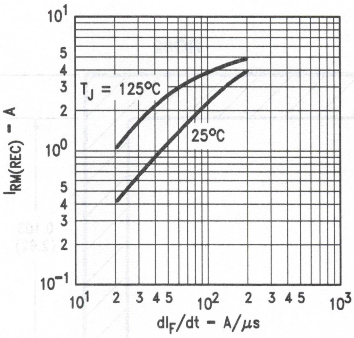
FIGURE 6. Typical Reverse Recovery Charge

Performance Characteristics (Continued)



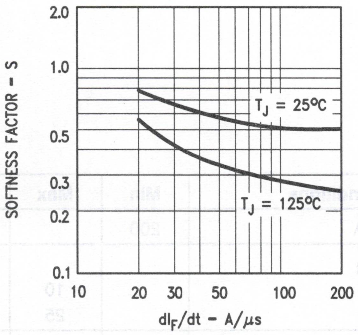
TL/G/10039-8

FIGURE 7. Typical Reverse Recovery Time



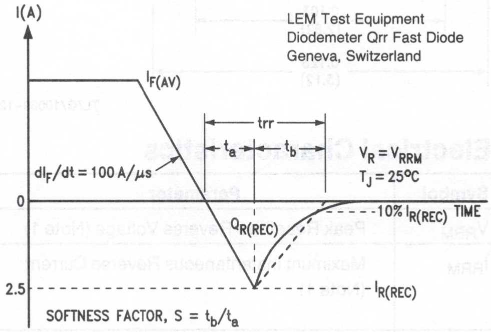
TL/G/10039-9

FIGURE 8. Maximum Reverse Recovery Current



TL/G/10039-10

FIGURE 9. Typical Reverse Recovery Softness



LEM Test Equipment
Diodemeter Qrr Fast Diode
Geneva, Switzerland

TL/G/10039-11

FIGURE 10. Reverse Recovery Test Waveform

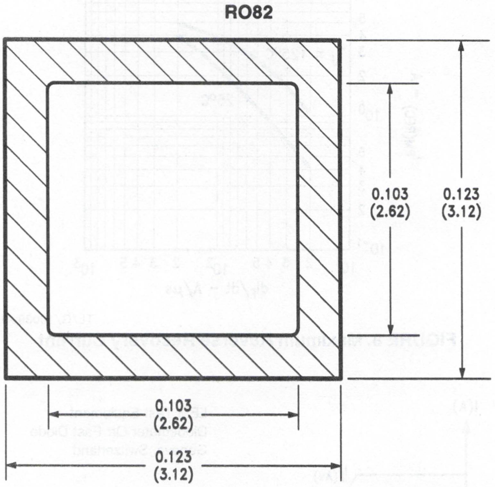
Probe Testing

Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips. These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process R5
Ultra-fast Rectifier



TL/G/10039-12

DESCRIPTION

These dice are designed especially for use in switching power supplies, inverters and PWM motor controls. These dice feature low reverse recovery current with soft recovery.

Electrical Characteristics

Symbol	Parameter	Conditions	Min	Max	Units
V_{RRM}	Peak Repetitive Reverse Voltage (Note 1)	$I_R = 0.5$ mA	200		V
I_{RRM}	Maximum Instantaneous Reverse Current (Note 1)	$V_R = V_{RRM}$ $T_J = 125°C$ $T_J = 25°C$		 10 25	 mA μA
V_{FM}	Maximum Instantaneous Forward Voltage	$I_F = 16A$	0.8		V
$I_{R\,(rec)}$	Maximum Reverse Recovery Current (Note 2)	$I_F = 16A$; $V_R = V_{RRM}$ $dI_F/dt = 100A/\mu s$		2.5	A
t_{RR}	Maximum Reverse Recovery Time	$I_F = 1A$; $dI_F/dt = 50A/\mu s$ $I_F = 16A$; $dI_F/dt = 100A/\mu s$		35 50	ns ns

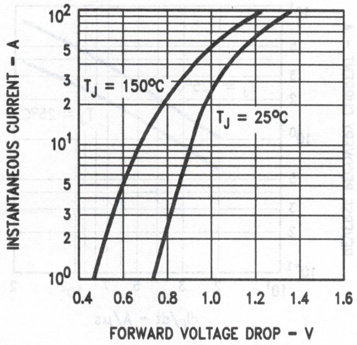
Note 1: Pulse Test: Pulse Width = 300 μs. Duty Cycle ≤ 2.0%.
Note 2: See *Figure 10* for test conditions.

This process is available in the following device types:

TO-247 (Case 40)	TO-220AC (Case 41)
FRK3205CC	FRP1605
FRK3210CC	FRP1610
FRK3215CC	FRP1615
FRK3220CC	FRP1620

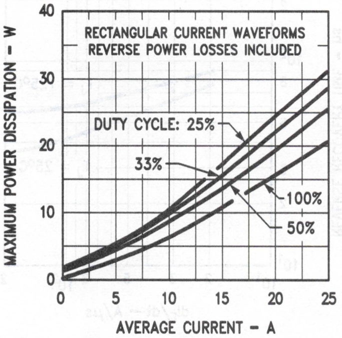
FRP #	1605	1610	1615	1620	FRK #	3205CC	3210CC	3215CC	3220CC	Unit
V_{RM} ($I_R = 0.5$ mA)	50	100	150	200	V_{RM} ($I_R = 0.5$ mA)	50	100	150	200	V

Performance Characteristics



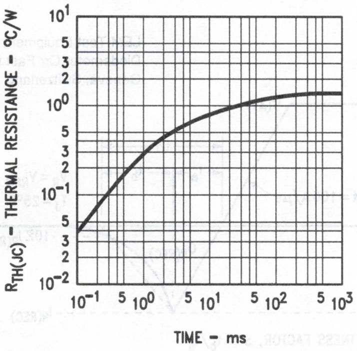
TL/G/10039-13

FIGURE 1. Maximum Forward Voltage Drop



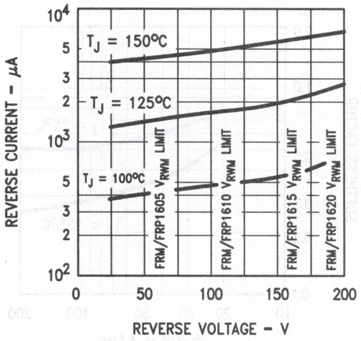
TL/G/10039-14

FIGURE 2. Maximum Power Dissipation



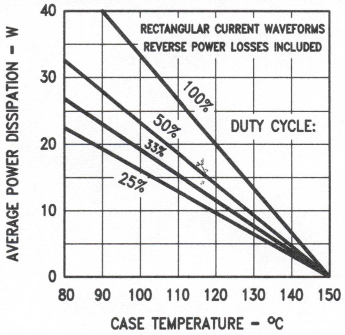
TL/G/10039-15

FIGURE 3. Maximum Transient Thermal Resistance



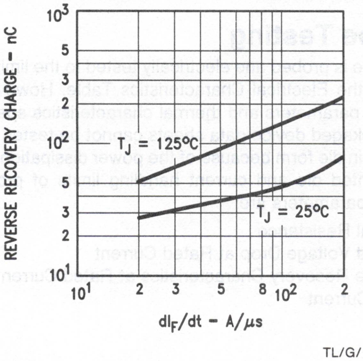
TL/G/10039-16

FIGURE 4. Typical Reverse Leakage Current



TL/G/10039-17

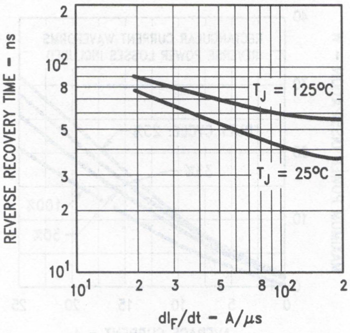
FIGURE 5. Power Derating



TL/G/10039-18

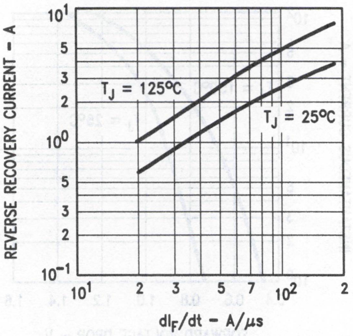
FIGURE 6. Typical Reverse Recovery Charge

Performance Characteristics (Continued)



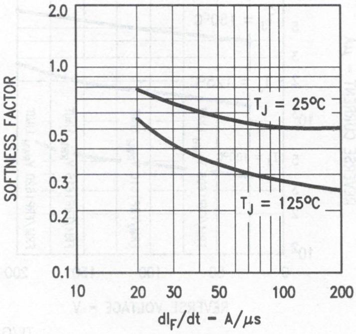
TL/G/10039-19

FIGURE 7. Typical Reverse Recovery Time



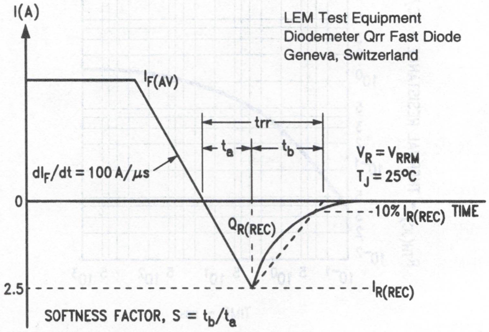
TL/G/10039-20

FIGURE 8. Maximum Reverse Recovery Current



TL/G/10039-21

FIGURE 9. Typical Reverse Recovery Softness


I(A)
LEM Test Equipment
Diodemeter Qrr Fast Diode
Geneva, Switzerland
I_F(AV)
trr
t_a
t_b
V_R = V_RRM
T_J = 25°C
dI_F/dt = 100 A/μs
0
-10% I_R(REC)
TIME
Q_R(REC)
2.5
I_R(REC)
SOFTNESS FACTOR, S = t_b/t_a

TL/G/10039-22

FIGURE 10. Reverse Recovery Test Waveform

Probe Testing

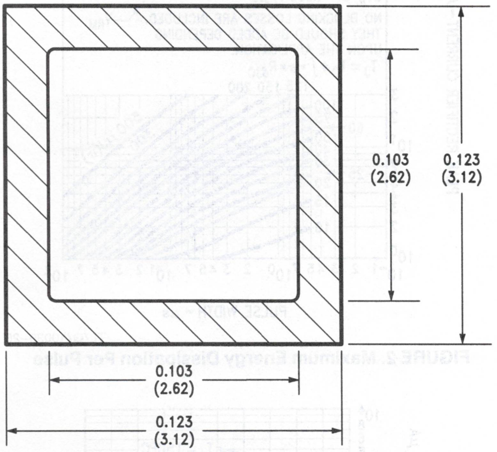
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips. These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process R6
Ultra-Fast Rectifier

RO96



TL/G/10039-23

DESCRIPTION

These dice are designed especially for use in switching power supplies, inverters and PWM motor controls. These dice feature low reverse recovery current with soft recovery.

Electrical Characteristics

Symbol	Parameter	Conditions	Min	Max	Units
V_{RRM}	Peak Repetitive Reverse Voltage	$I_R = 0.5$ mA	600		V
I_{RRM}	Maximum Instantaneous Reverse Current (Note 1)	$V_R = V_{RRM}$ $T_J = 125°C$ $T_J = 25°C$		 5 10	 mA μA
V_{FM}	Maximum Instantaneous Forward Voltage (Note 1)	$I_F = 8A$		1.5	V
$I_{R\ (rec)}$	Maximum Reverse Recovery Current (Note 2)	$I_F = 8A$; $V_R = 200V$ $dI_F/dt = 100A/\mu s$		5	A
t_{RR}	Maximum Reverse Recovery Time	$I_F = 8A$; $dI_F/dt = 100A/\mu s$		75	ns

Note 1: Pulse width = 300 μs. Duty Cycle ≤ 2.0%.

Note 2: See *Figure 8* for test conditions.

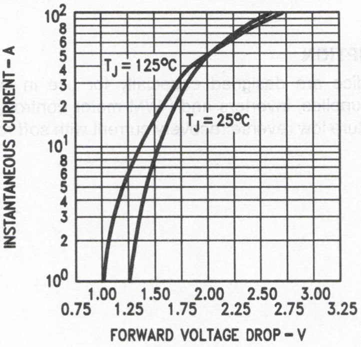
This process is available in the following device types:

TO-220AB (Case 38)	TO-220AC Case (41)
FRP1640CC	FRP840
FRP1650CC	FRP850
FRP1660CC	FRP860

FRP #	840	850	860	1640CC	1650CC	1660CC	Unit
V_{RRM} ($I_R = 0.5$ mA)	400	500	600	400	500	600	V

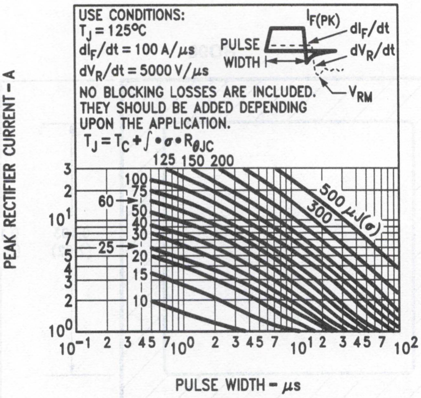
Process R6

Performance Characteristics



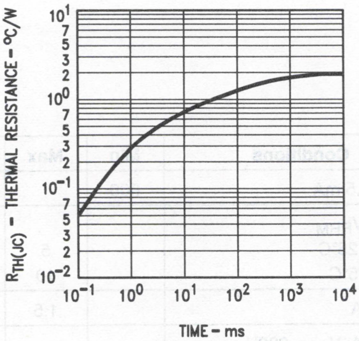
TL/G/10039-24

FIGURE 1. Maximum Forward Voltage Drop



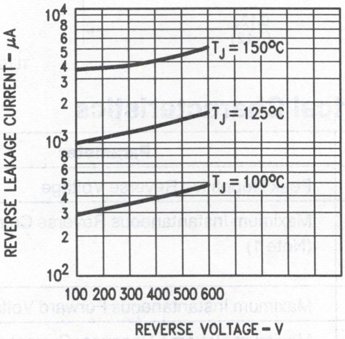
TL/G/10039-25

FIGURE 2. Maximum Energy Dissipation Per Pulse



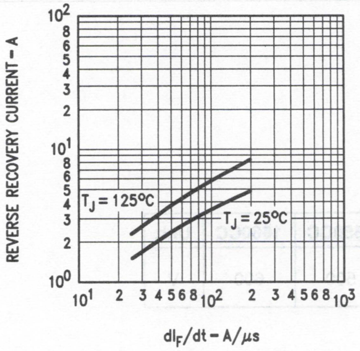
TL/G/10039-26

FIGURE 3. Maximum Transient Thermal Resistance



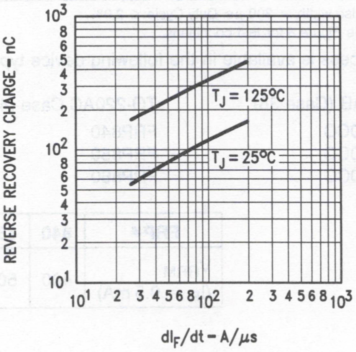
TL/G/10039-27

FIGURE 4. Typical Reverse Leakage Current



TL/G/10039-28

FIGURE 5. Typical Reverse Recovery Current

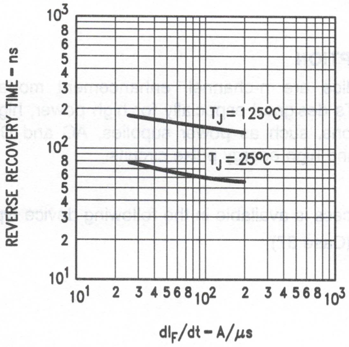


TL/G/10039-29

FIGURE 6. Typical Reverse Recovery Charge

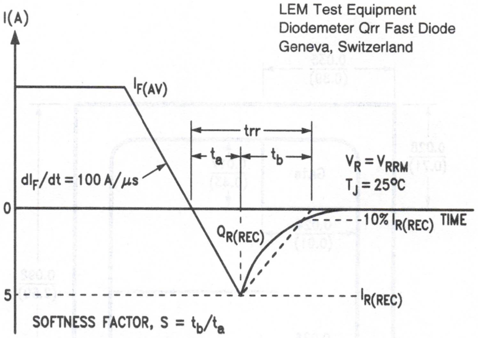
Process R6

Performance Characteristics (Continued)



TL/G/10039-30

FIGURE 7. Typical Reverse Recovery Time


I(A)
$I_{F(AV)}$
trr
t_a
t_b
$V_R = V_{RRM}$
$T_J = 25°C$
$dI_F/dt = 100$ A/µs
0
$Q_{R(REC)}$
-10% $I_{R(REC)}$
TIME
5
$I_{R(REC)}$
SOFTNESS FACTOR, $S = t_b/t_a$

LEM Test Equipment
Diodemeter Qrr Fast Diode
Geneva, Switzerland

TL/G/10039-31

FIGURE 8. Reverse Recovery Test Waveform

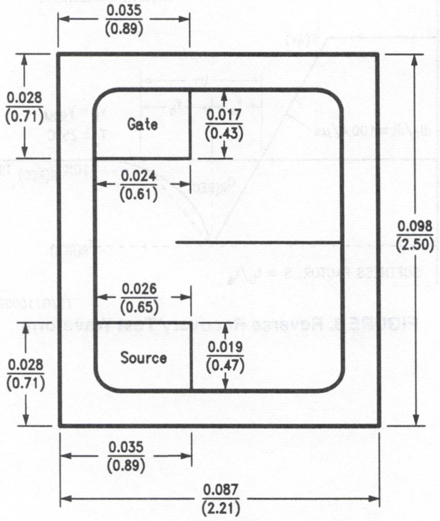
Probe Testing

Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips. These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process A1
N-Channel Power MOSFET



TL/G/10040–1

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:
TO-220 (Case 37)
IRF510
IRF511
IRF512
IRF513
MTP4N08
MTP4N10

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	100		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 2.0A$		0.60	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 2.0A$	1.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		200	pF
C_{oss}	Output Capacitance			100	pF
C_{rss}	Reverse Transfer			30	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 50V$; $I_D = 2.0A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		20	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		25	ns
$t_{d(off)}$	Turn-Off Delay Time			25	ns
t_f	Fall Time			20	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 8.0A$ $V_{DD} = 40V$		7.5	nC

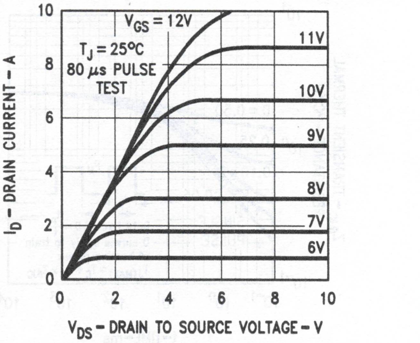
Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

Note 3: Switching time measurements performed on LEM TR-58 test equipment.

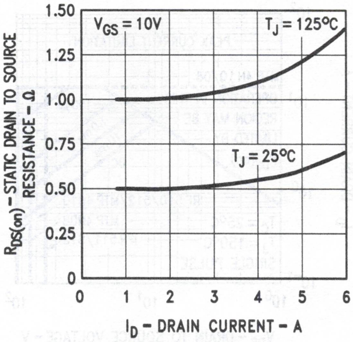
Process A1

Typical Performance Characteristics



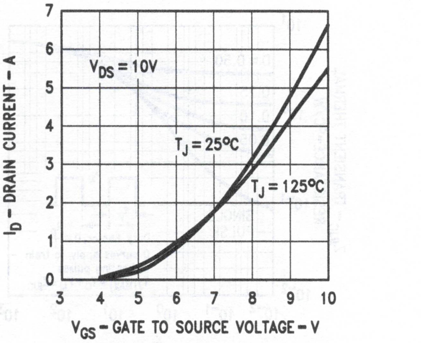
TL/G/10040–2

FIGURE 1. Output Characteristics



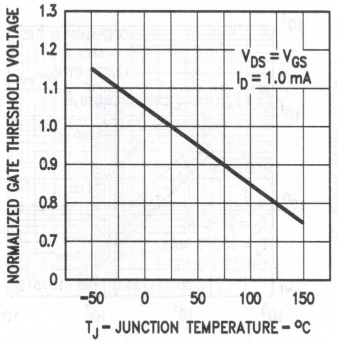
TL/G/10040–3

FIGURE 2. Static Drain to Source Resistance vs Drain Current



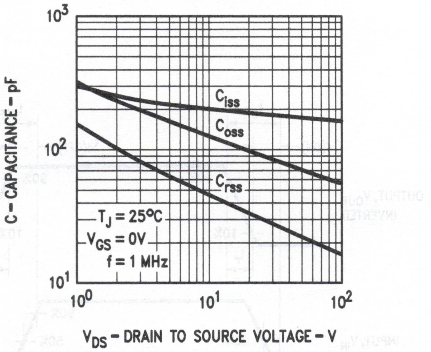
TL/G/10040–4

FIGURE 3. Transfer Characteristics



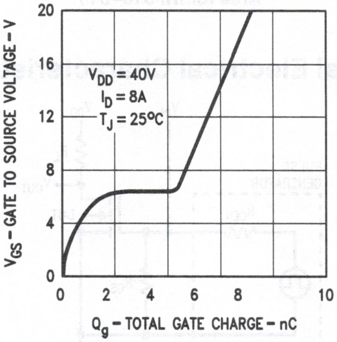
TL/G/10040–5

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–6

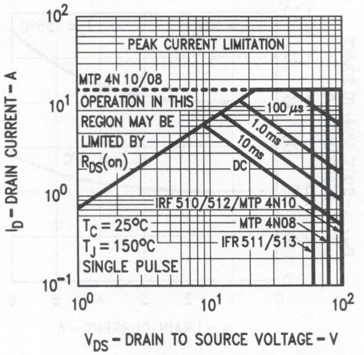
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–7

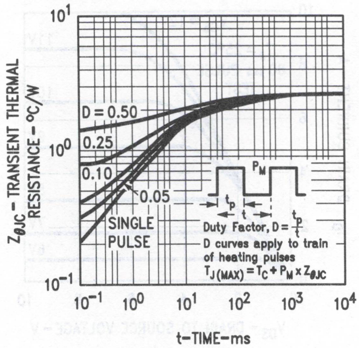
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



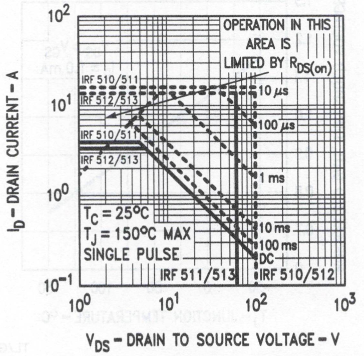
TL/G/10040-8

FIGURE 7. Forward Biased Safe Operating Area for MTP4N08/4N10



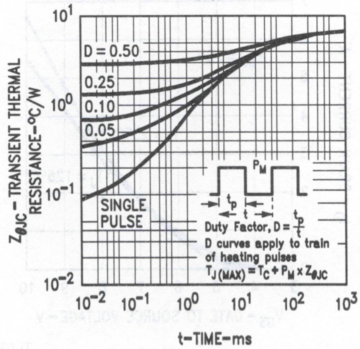
TL/G/10040-9

FIGURE 8. Transient Thermal Resistance vs Time for MTP4N08/4N10



TL/G/10040-10

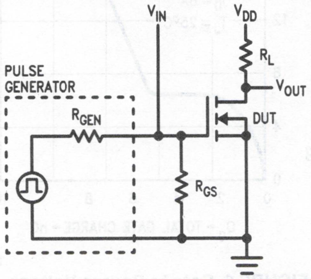
FIGURE 9. Forward Biased Safe Operating Area for IRF510-513



TL/G/10040-11

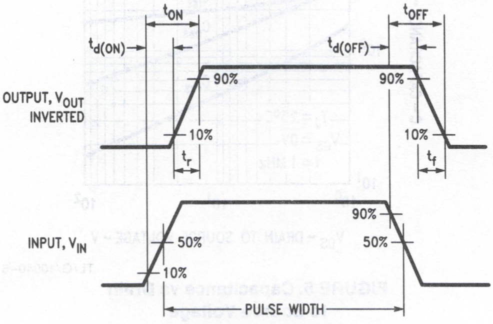
FIGURE 10. Transient Thermal Resistance vs Time for IRF510-513

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10040-12

FIGURE 11. Switching Test Circuit

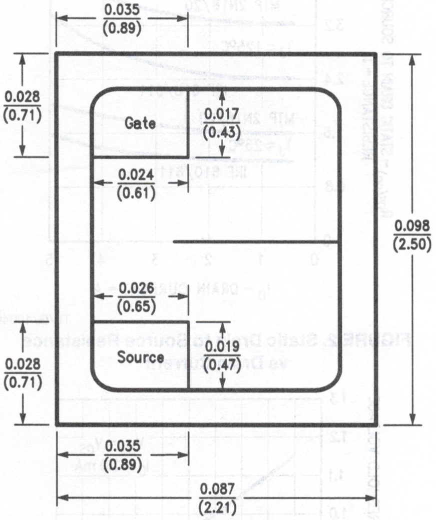

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10040-13

FIGURE 12. Switching Waveforms

National Semiconductor

Process A2
N-Channel Power MOSFET



TL/G/10040-14

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-220 (Case 37)
IRF610
IRF611
IRF612
IRF613
MTP2N18
MTP2N20

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

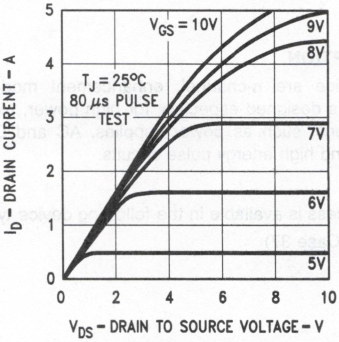
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	200		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 1.25A$		1.5	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 1.25A$	0.8		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ $f = 1\ MHz$		200	pF
C_{oss}	Output Capacitance			80	pF
C_{rss}	Reverse Transfer			25	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 50V$; $I_D = 1.25A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		15	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		25	ns
$t_{d(off)}$	Turn-Off Delay Time			15	ns
t_f	Fall Time			15	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 3.0A$ $V_{DD} = 45V$		7.5	nC

Note 1: T_J = +25°C to +150°C.

Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

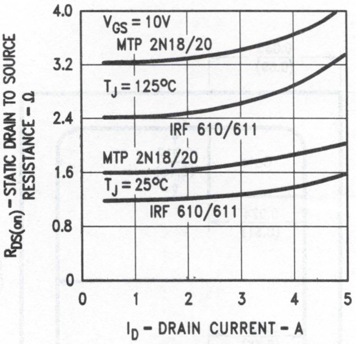
Note 3: Switching time measurements performed on LEM TR-58 test equipment.

Typical Performance Characteristics



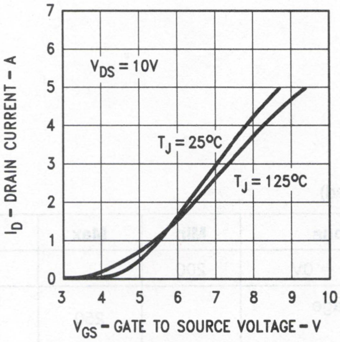
TL/G/10040–15

FIGURE 1. Output Characteristics



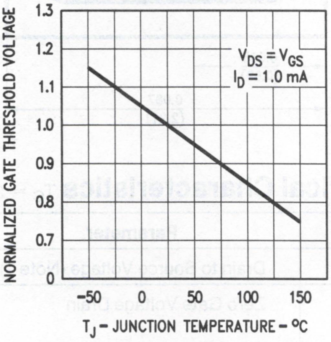
TL/G/10040–16

FIGURE 2. Static Drain to Source Resistance vs Drain Current



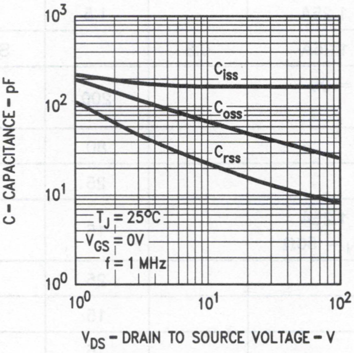
TL/G/10040–17

FIGURE 3. Transfer Characteristics



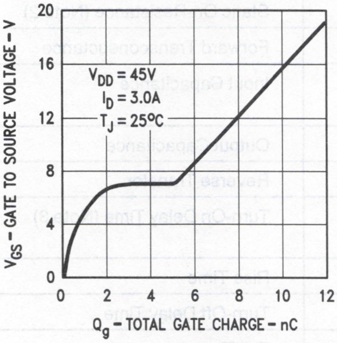
TL/G/10040–18

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–19

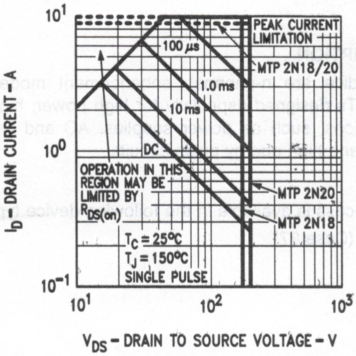
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–20

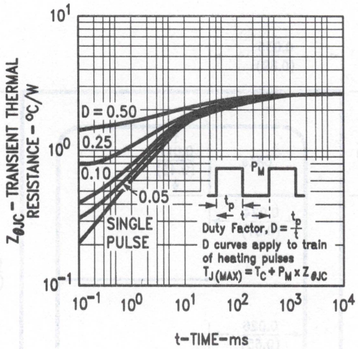
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



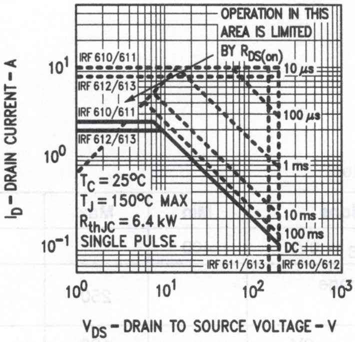
TL/G/10040-21

FIGURE 7. Forward Biased Safe Operating Area for MTP2N18/2N20



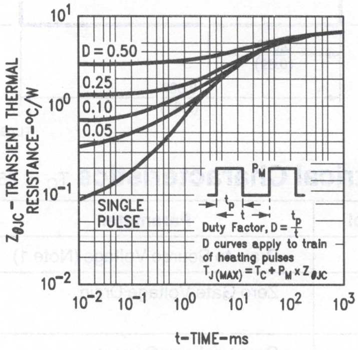
TL/G/10040-22

FIGURE 8. Transient Thermal Resistance vs Time for MTP2N18/2N20



TL/G/10040-23

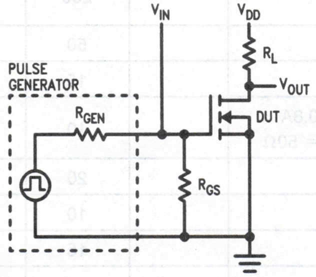
FIGURE 9. Forward Biased Safe Operating Area for IRF610-613



TL/G/10040-24

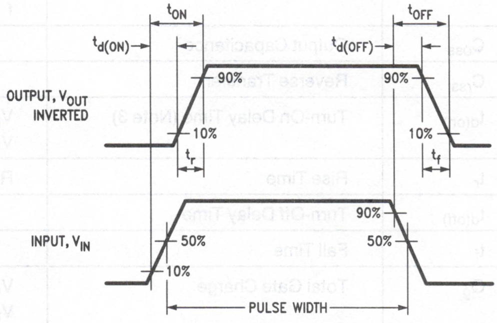
FIGURE 10. Transient Thermal Resistance vs Time for IRF610-613

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
PULSE GENERATOR
R_{GEN}
DUT
R_{GS}

TL/G/10040-25

FIGURE 11. Switching Test Circuit

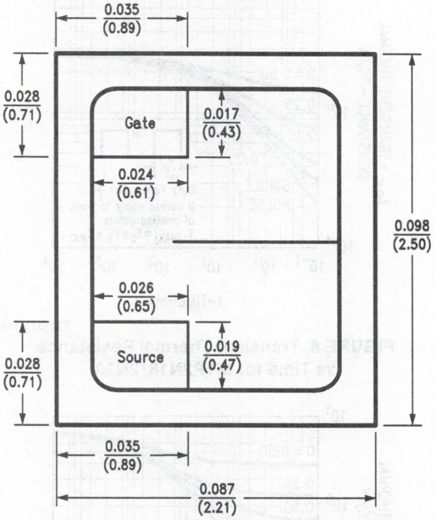

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10040-26

FIGURE 12. Switching Waveforms

National Semiconductor

Process A3
N-Channel Power MOSFET



TL/G/10040-27

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-220 (Case 37)
IRF710
IRF711
IRF712
IRF713
MTP2N35
MTP2N40

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

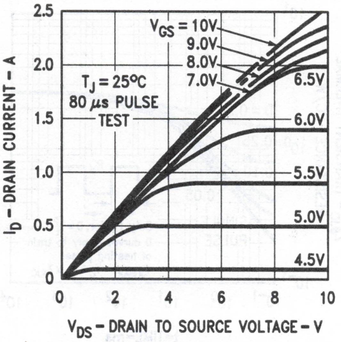
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	400		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 2.0A$		3.6	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 2.0A$	0.5		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		200	pF
C_{oss}	Output Capacitance			50	pF
C_{rss}	Reverse Transfer			15	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 200V$; $I_D = 0.8A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		10	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		20	ns
$t_{d(off)}$	Turn-Off Delay Time			10	ns
t_f	Fall Time			15	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 2.0A$ $V_{DD} = 200V$		7.5	nC

Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

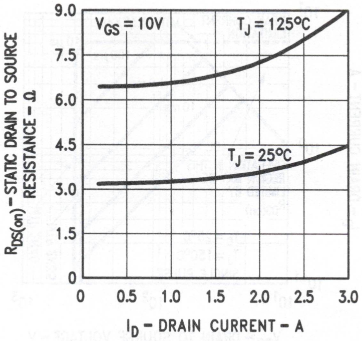
Note 3: Switching time measurements performed on LEM TR-58 test equipment.

Typical Performance Characteristics



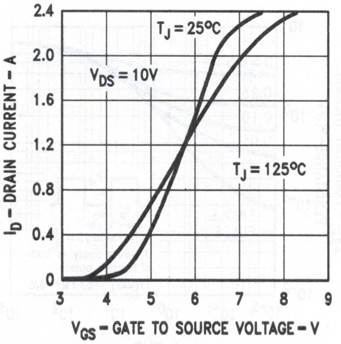
TL/G/10040–28

FIGURE 1. Output Characteristics



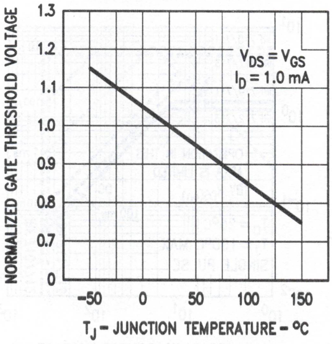
TL/G/10040–29

FIGURE 2. Static Drain to Source Resistance vs Drain Current



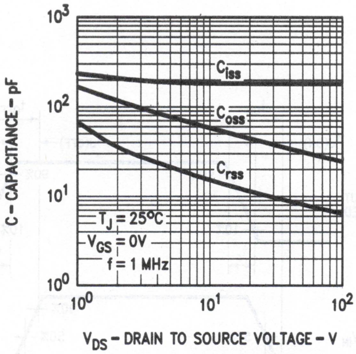
TL/G/10040–30

FIGURE 3. Transfer Characteristics



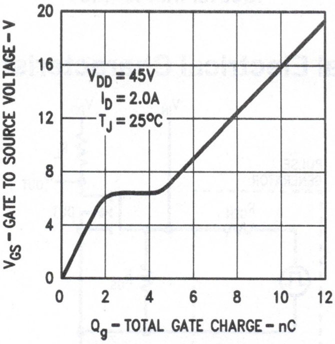
TL/G/10040–31

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–32

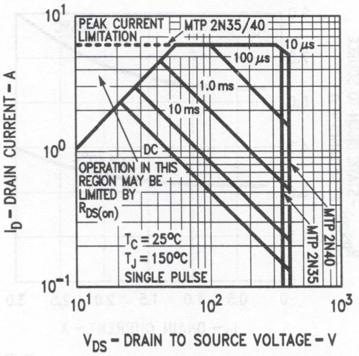
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–33

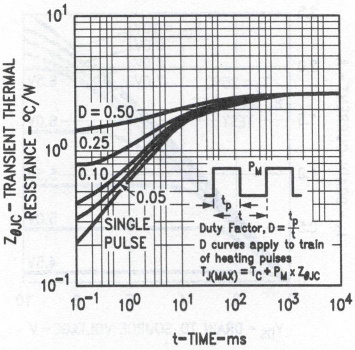
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



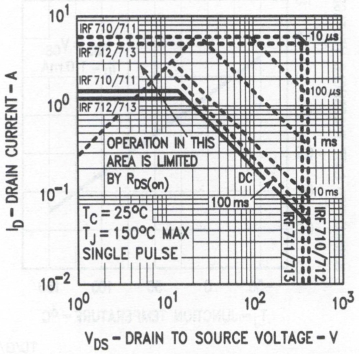
TL/G/10040-34

FIGURE 7. Forward Biased Safe Operating Area for MTP2N35/2N40



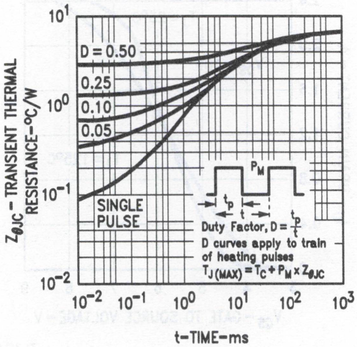
TL/G/10040-35

FIGURE 8. Transient Thermal Resistance vs Time for MTP2N35/2N40



TL/G/10040-36

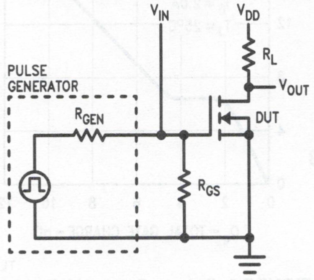
FIGURE 9. Forward Biased Safe Operating Area for IRF710-713



TL/G/10040-37

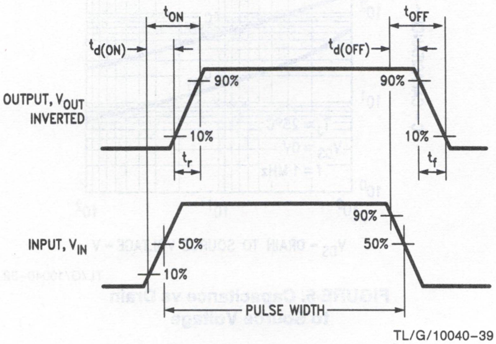
FIGURE 10. Transient Thermal Resistance vs Time for IRF710-713

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10040-38

FIGURE 11. Switching Test Circuit

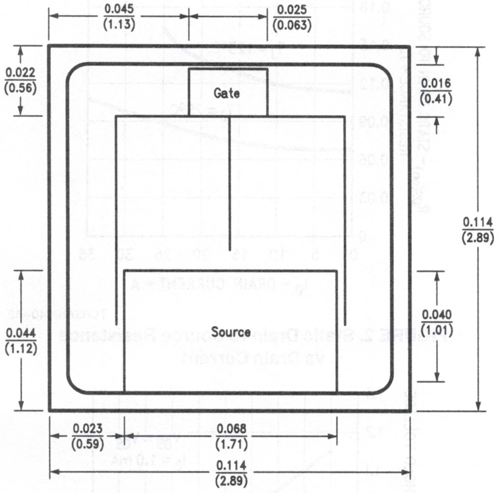

t_{ON}
$t_{d(ON)}$
t_{OFF}
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10040-39

FIGURE 12. Switching Waveforms

National Semiconductor

Process B1
N-Channel Power MOSFET



TL/G/10040-40

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-220 (Case 37)
FMP18N05
FMP20N05
FMP18N06
FMP20N06

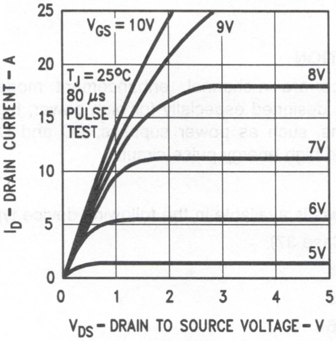
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A; V_{GS} = 0V$	50		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V; V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A; V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V; I_D = 10A$		0.085	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V; I_D = 10A$	5		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V; V_{GS} = 0V$ f = 1 MHz		850	pF
C_{oss}	Output Capacitance			400	pF
C_{rss}	Reverse Transfer			150	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 40V; I_D = 10A$ $V_{GS} = 10V; R_{GEN} = 50\Omega$		50	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		90	ns
$t_{d(off)}$	Turn-Off Delay Time			60	ns
t_f	Fall Time			75	ns
Q_g	Total Gate Charge	$V_{GS} = 10V; I_D = 25A$ $V_{DD} = 40V$		20	nC

Note 1: $T_J = +25°C$ to $+150°C$.

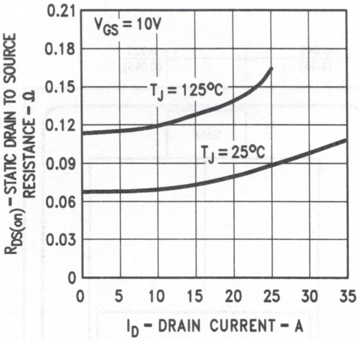
Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



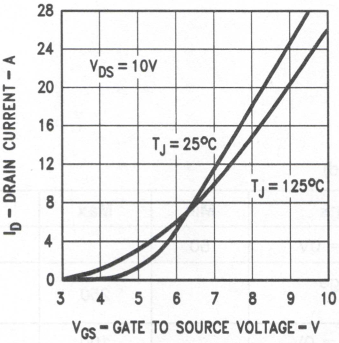
TL/G/10040-41

FIGURE 1. Output Characteristics



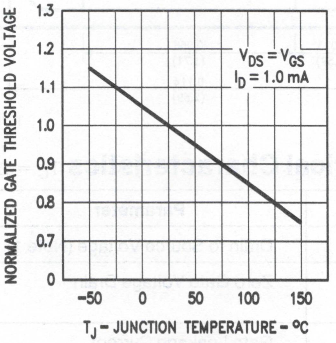
TL/G/10040-42

FIGURE 2. Static Drain to Source Resistance vs Drain Current



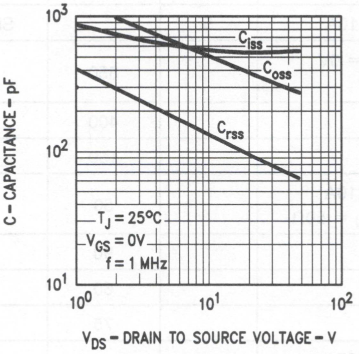
TL/G/10040-43

FIGURE 3. Transfer Characteristics



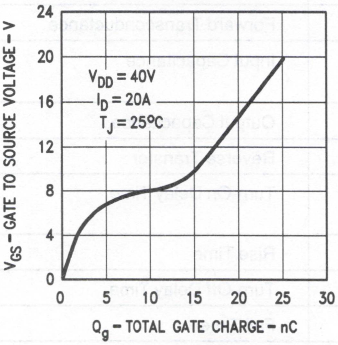
TL/G/10040-44

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040-45

FIGURE 5. Capacitance vs Drain to Source Voltage

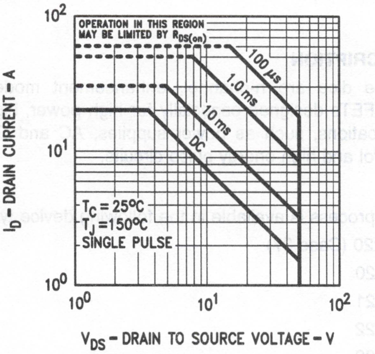


TL/G/10040-46

FIGURE 6. Gate to Source Voltage vs Total Gate Charge

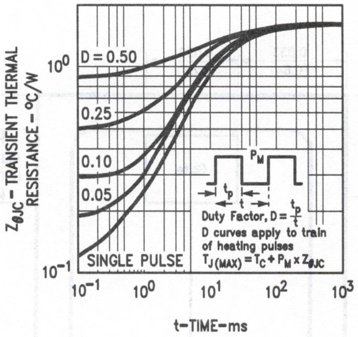
Process B1

Typical Performance Characteristics (Continued)



TL/G/10040-47

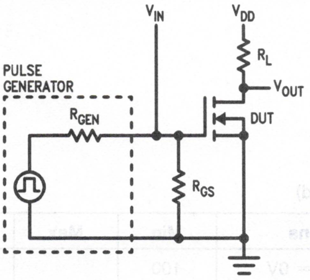
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10040-48

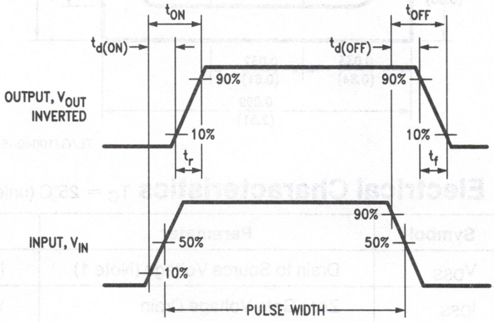
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10040-49

FIGURE 9. Switching Test Circuit

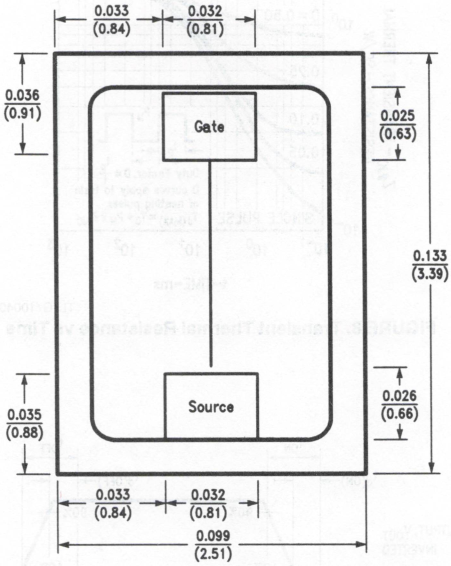

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10040-50

FIGURE 10. Switching Waveforms

National Semiconductor

Process B2
N-Channel Power MOSFET



TL/G/10040-51

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-220 (Case 37)
IRF520
IRF521
IRF522
IRF523
MTP10N08
MTP10N10

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

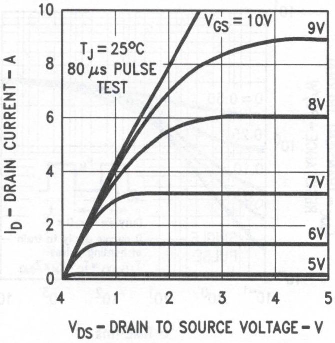
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	100		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2	4	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 4A$		0.30	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 4A$	1.5		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		600	pF
C_{oss}	Output Capacitance			400	pF
C_{rss}	Reverse Transfer			100	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 50V$; $I_D = 4A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		40	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		70	ns
$t_{d(off)}$	Turn-Off Delay Time			100	ns
t_f	Fall Time			70	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 10A$ $V_{DD} = 50V$		15	nC

Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse width limited by T_J.

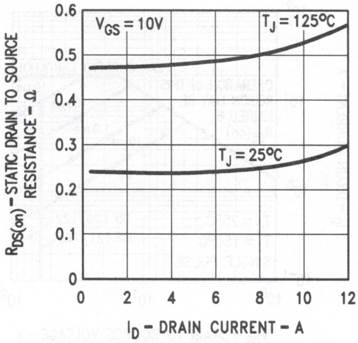
Note 3: Switching time measurements performed on LEM TR-58 test equipment.

Typical Performance Characteristics



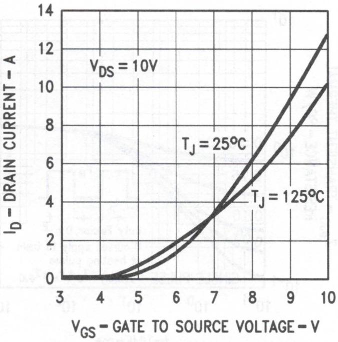
TL/G/10040–52

FIGURE 1. Output Characteristics



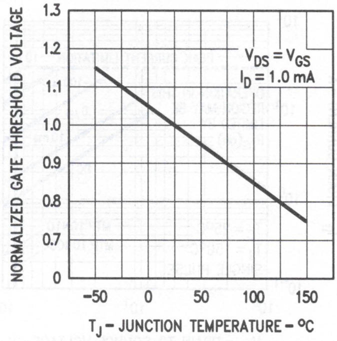
TL/G/10040–53

FIGURE 2. Static Drain to Source Resistance vs Drain Current



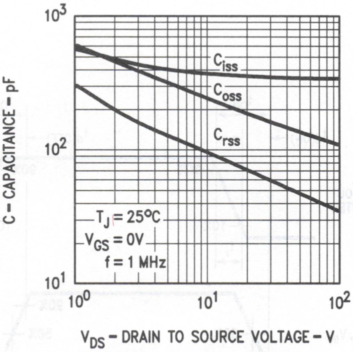
TL/G/10040–54

FIGURE 3. Transfer Characteristics



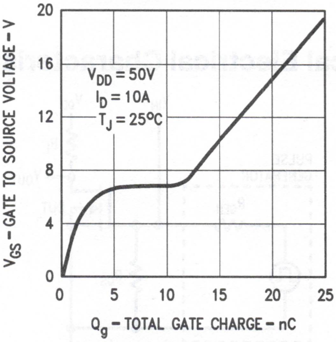
TL/G/10040–55

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–56

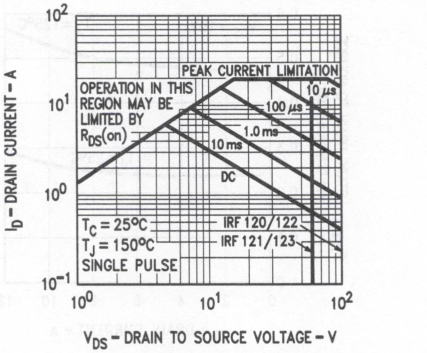
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–57

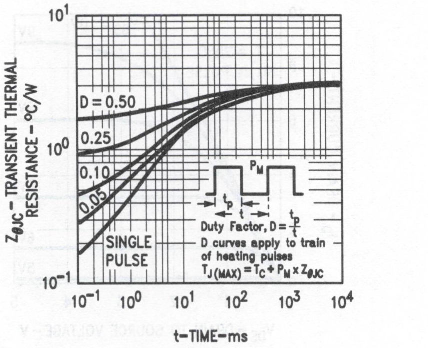
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



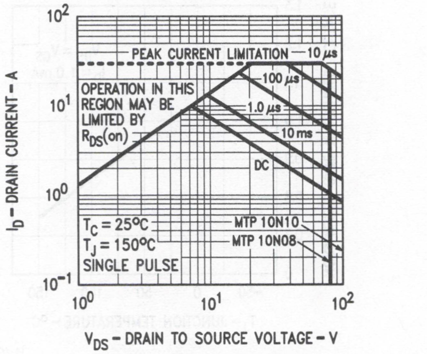
TL/G/10040–58

FIGURE 7. Forward Biased Safe Operating Area for IRF120–123 and IRF520–523



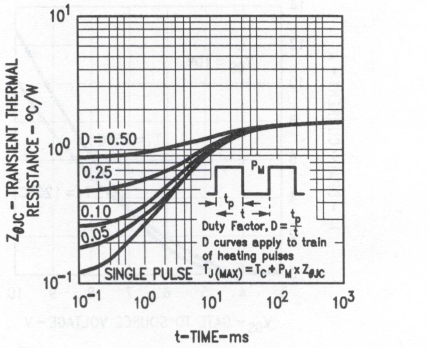
TL/G/10040–59

FIGURE 8. Transient Thermal Resistance vs Time for IRF120–123 and IRF520–523



TL/G/10040–60

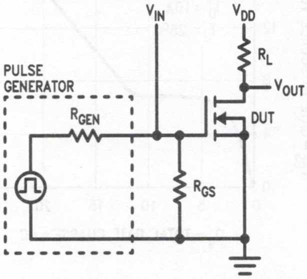
FIGURE 9. Forward Biased Safe Operating Area for MTP10N08/10N10



TL/G/10040–61

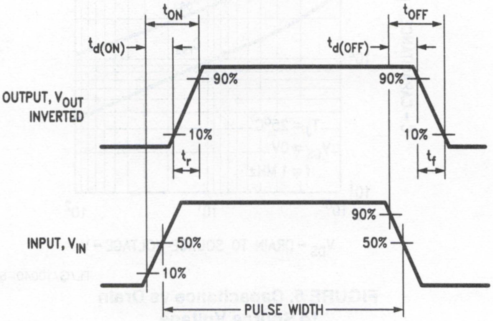
FIGURE 10. Transient Thermal Resistance vs Time for MTP10N08/10N10

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10040–62

FIGURE 11. Switching Test Circuit

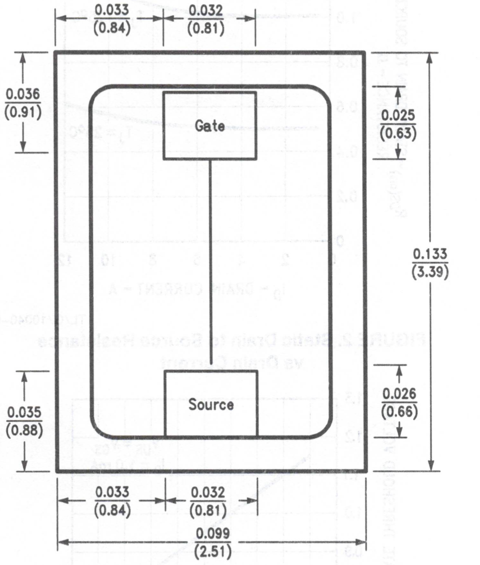

t_{ON}
$t_{d(ON)}$
t_{OFF}
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10040–63

FIGURE 12. Switching Waveforms

National Semiconductor

Process B3
N-Channel Power MOSFET



TL/G/10040-64

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-220 (Case 37)
IRF620
IRF621
IRF622
IRF623
MTP7N18
MTP7N20

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	200		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 2.5A$		0.8	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 2.5A$	1.3		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		600	pF
C_{oss}	Output Capacitance			300	pF
C_{rss}	Reverse Transfer			80	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 100V$; $I_D = 2.5A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		40	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		60	ns
$t_{d(off)}$	Turn-Off Delay Time			100	ns
t_f	Fall Time			60	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 6.0A$ $V_{DD} = 45V$		15	nC

Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse width limited by T_J.

Note 3: Switching time measurements performed on LEM TR-58 test equipment.

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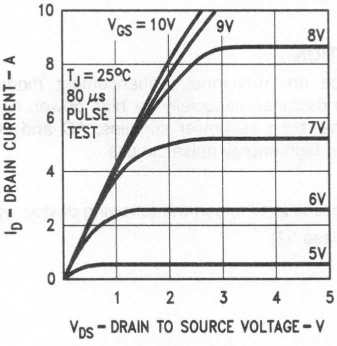
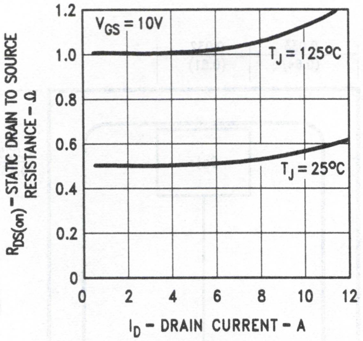
Typical Performance Characteristics



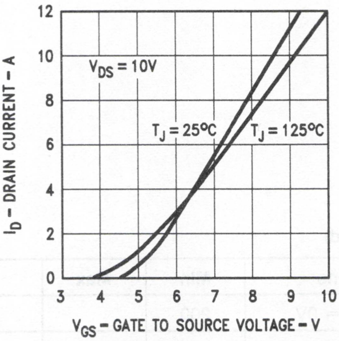
TL/G/10040-65

FIGURE 1. Output Characteristics



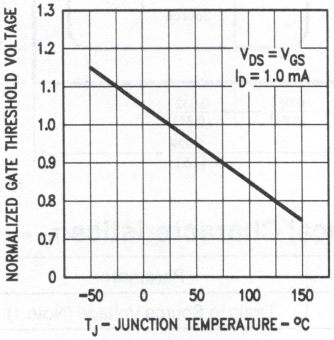
TL/G/10040-66

FIGURE 2. Static Drain to Source Resistance vs Drain Current



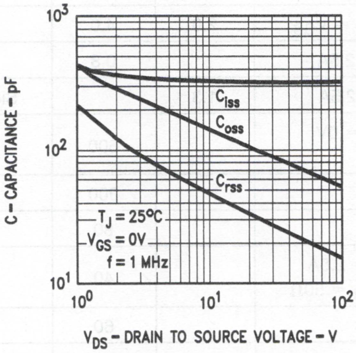
TL/G/10040-67

FIGURE 3. Transfer Characteristics



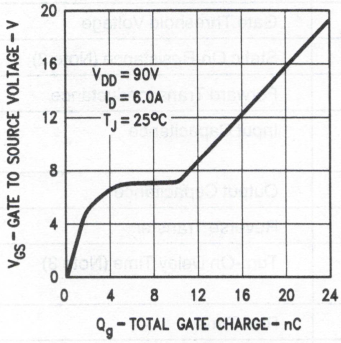
TL/G/10040-68

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040-69

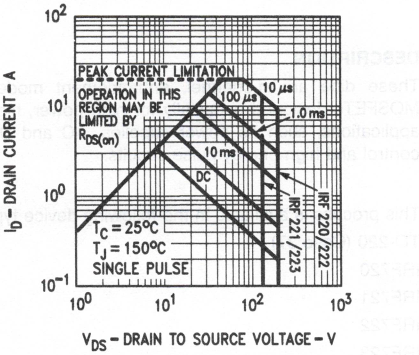
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040-70

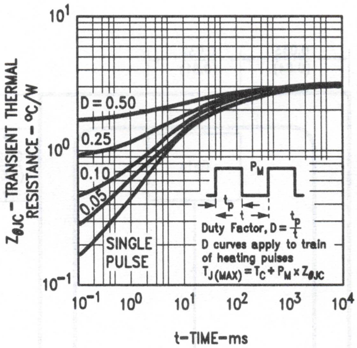
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



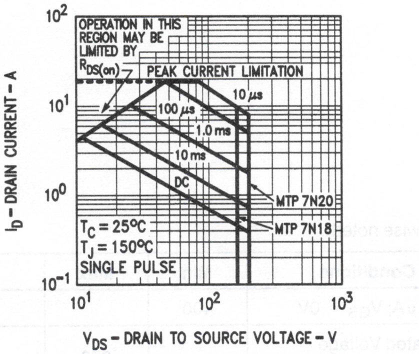
TL/G/10040-71

FIGURE 7. Forward Biased Safe Operating Area for IRF220–223 and IRF620–623



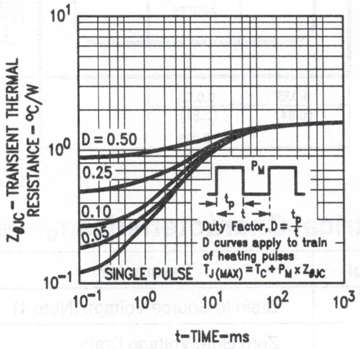
TL/G/10040-72

FIGURE 8. Transient Thermal Resistance vs Time for IRF220–223 and IRF620–623



TL/G/10040-73

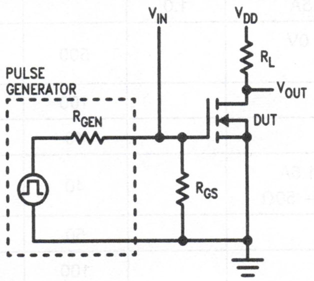
FIGURE 9. Forward Biased Safe Operating Area for MTP7N18/7N20



TL/G/10040-74

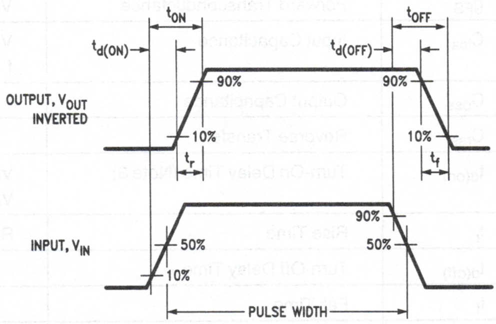
FIGURE 10. Transient Thermal Resistance vs Time for MTP7N18/7N20

Typical Electrical Characteristics


V_IN
V_DD
R_L
V_OUT
DUT
PULSE GENERATOR
R_GEN
R_GS

TL/G/10040-75

FIGURE 11. Switching Test Circuit

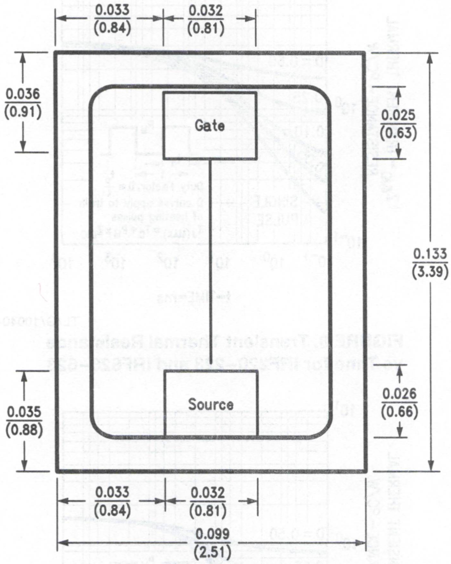

t_ON
t_OFF
t_d(ON)
t_d(OFF)
90%
90%
OUTPUT, V_OUT INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_IN
50%
50%
10%
PULSE WIDTH

TL/G/10040-76

FIGURE 12. Switching Waveforms

National Semiconductor

Process B4
N-Channel Power MOSFET



TL/G/10040-77

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-220 (Case 37)
IRF720
IRF721
IRF722
IRF723
MTP3N35
MTP3N40

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

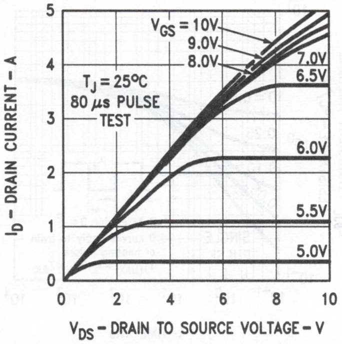
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	400		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 1.5A$		1.8	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 1.5A$	1.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ $f = 1$ MHz		500	pF
C_{oss}	Output Capacitance			100	pF
C_{rss}	Reverse Transfer			40	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 200V$; $I_D = 1.5A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		40	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		50	ns
$t_{d(off)}$	Turn-Off Delay Time			100	ns
t_f	Fall Time			50	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 4.0A$ $V_{DD} = 200V$		15	nC

Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

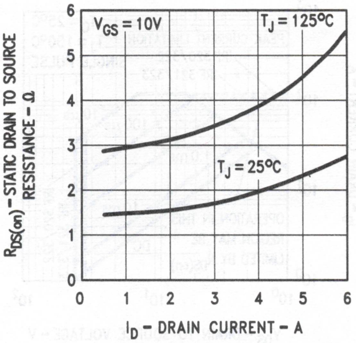
Note 3: Switching time measurements performed on LEM TR-58 test equipment.

Typical Performance Characteristics



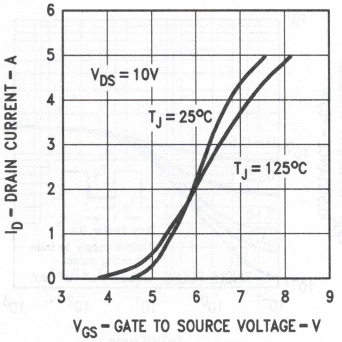
TL/G/10040–78

FIGURE 1. Output Characteristics



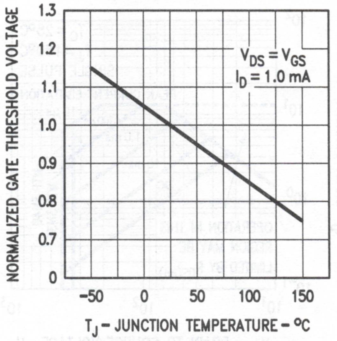
TL/G/10040–79

FIGURE 2. Static Drain to Source Resistance vs Drain Current



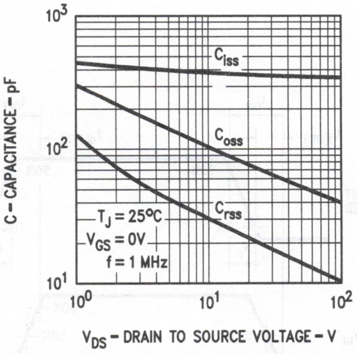
TL/G/10040–80

FIGURE 3. Transfer Characteristics



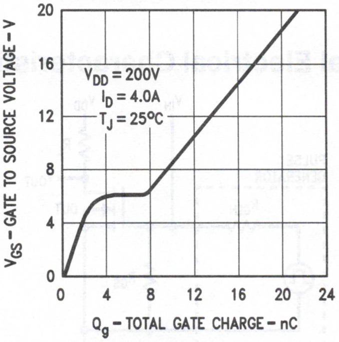
TL/G/10040–81

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–82

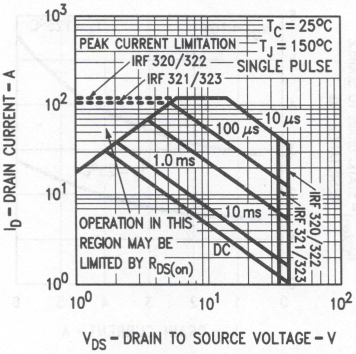
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–83

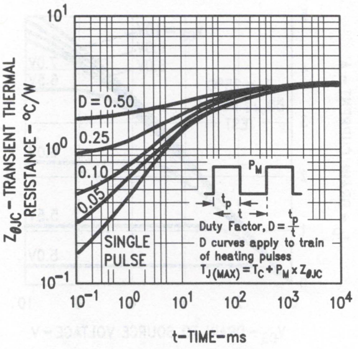
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



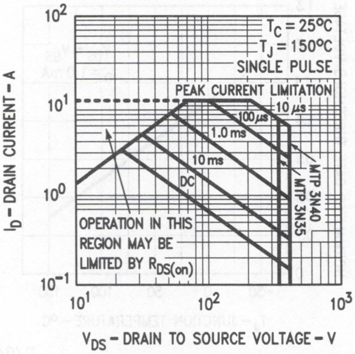
TL/G/10040–84

FIGURE 7. Forward Biased Safe Operating Area for IRF320–323 and IRF720–723



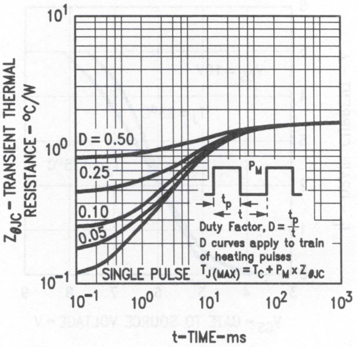
TL/G/10040–85

FIGURE 8. Transient Thermal Resistance vs Time for IRF320–323 and IRF720–723



TL/G/10040–86

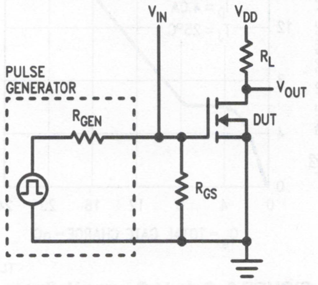
FIGURE 9. Forward Biased Safe Operating Area for MTP3N35/3N40



TL/G/10040–87

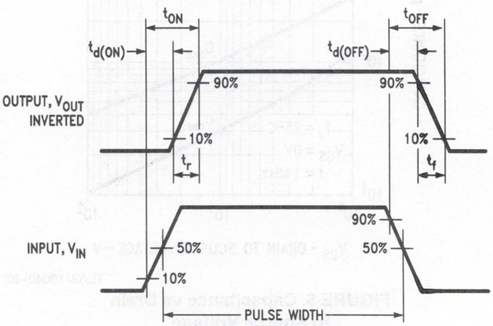
FIGURE 10. Transient Thermal Resistance vs Time for MTP3N35/3N40

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10040–88

FIGURE 11. Switching Test Circuit

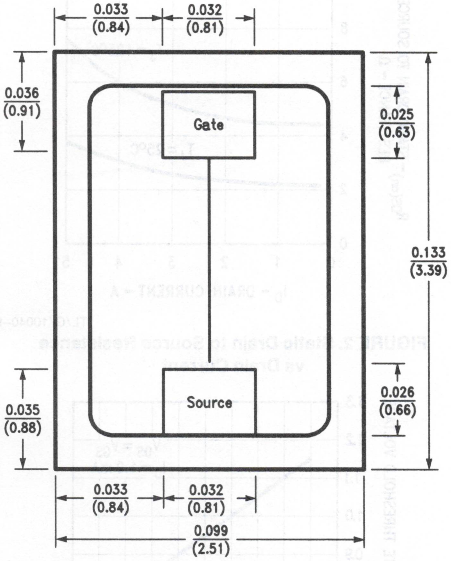

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10040–89

FIGURE 12. Switching Waveforms

National Semiconductor

Process B5
N-Channel Power MOSFET



TL/G/10040-90

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF420	IRF820
IRF421	IRF821
IRF422	IRF822
IRF423	IRF823
	MTP2N45
	MTP2N50

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	500		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 1A$		3.0	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 1A$	1.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		400	pF
C_{oss}	Output Capacitance			100	pF
C_{rss}	Reverse Transfer			40	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 250V$; $I_D = 1A$ $V_{GS} = 10V$; $R_{GEN} = 50\Omega$		40	ns
t_r	Rise Time	$R_{GS} = 50\Omega$		50	ns
$t_{d(off)}$	Turn-Off Delay Time			60	ns
t_f	Fall Time			60	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 3.0A$ $V_{DD} = 200V$		15	nC

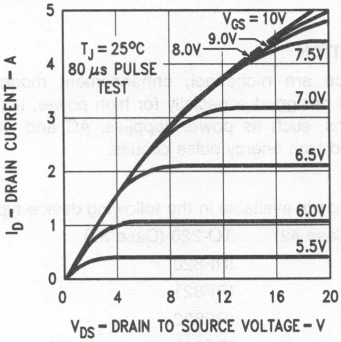
Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse width limited by T_J.

Note 3: Switching time measurements performed on LEM TR-58 test equipment.

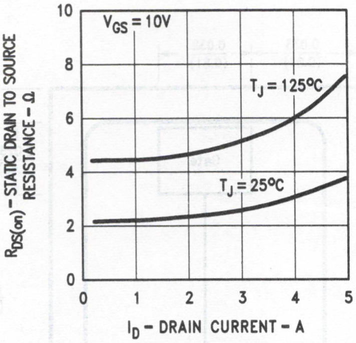
Process B5

Typical Performance Characteristics



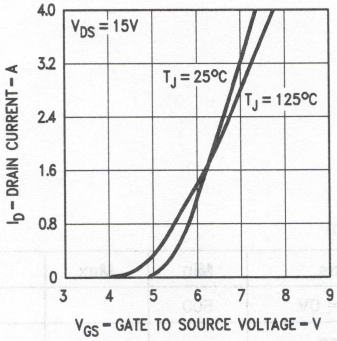
TL/G/10040–91

FIGURE 1. Output Characteristics



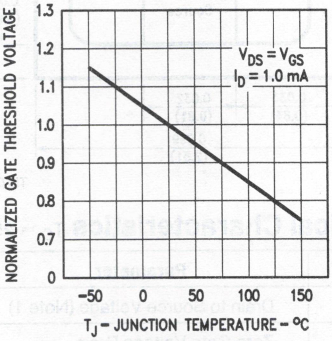
TL/G/10040–92

FIGURE 2. Static Drain to Source Resistance vs Drain Current



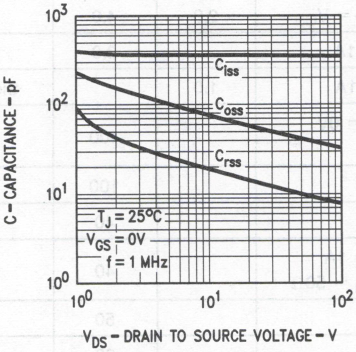
TL/G/10040–93

FIGURE 3. Transfer Characteristics



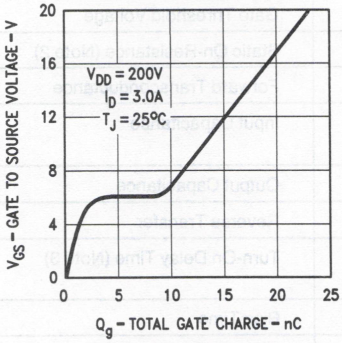
TL/G/10040–94

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–95

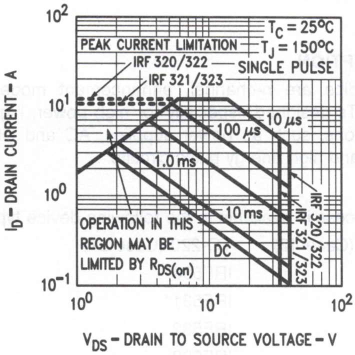
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–96

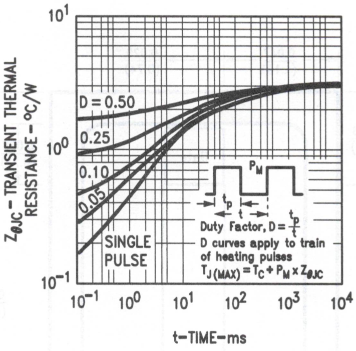
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



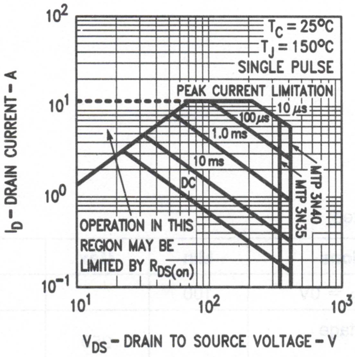
TL/G/10040-97

FIGURE 7. Forward Biased Safe Operating Area for IRF320–323 and IRF720–723



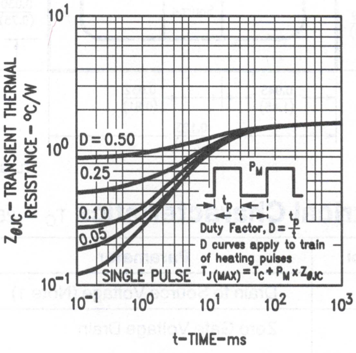
TL/G/10040-98

FIGURE 8. Transient Thermal Resistance vs Time for IRF320–323 and IRF720–723



TL/G/10040-99

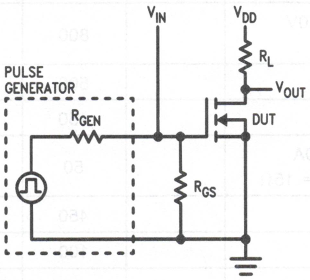
FIGURE 9. Forward Biased Safe Operating Area for MTP3N35/3N40



TL/G/10040-A0

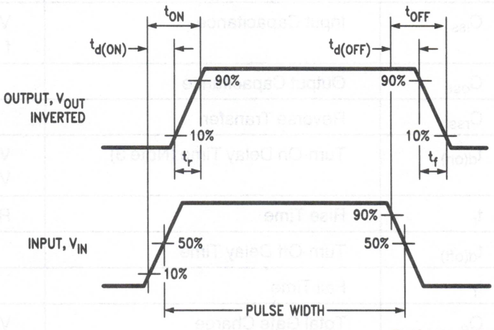
FIGURE 10. Transient Thermal Resistance vs Time for MTP3N35/3N40

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10040-A1

FIGURE 11. Switching Test Circuit

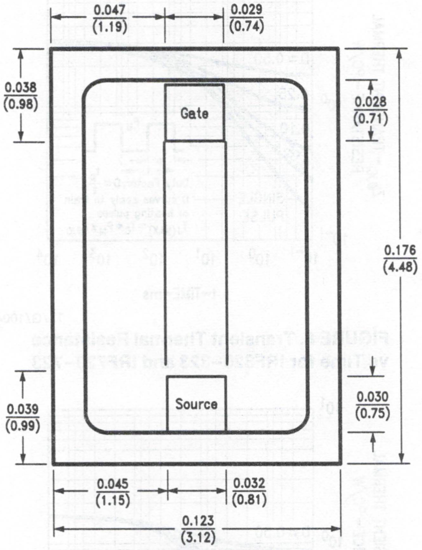

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10040-A2

FIGURE 12. Switching Waveforms

National Semiconductor

Process C1
N-Channel Power MOSFET



TL/G/10040–A3

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF130	IRF530
IRF131	IRF531
IRF132	IRF532
IRF133	IRF533
	MTP20N08
	MTP20N10

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

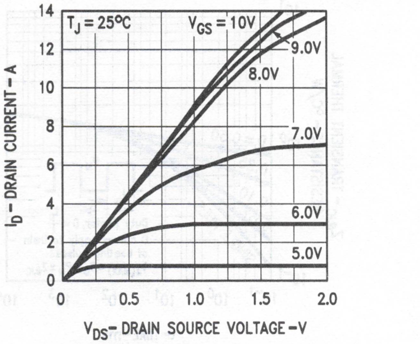
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	100		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 8A$		0.18	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 8A$	4.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		800	pF
C_{oss}	Output Capacitance			500	pF
C_{rss}	Reverse Transfer			150	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 25V$; $I_D = 10A$ $V_{GS} = 10V$; $R_{GEN} = 15\Omega$		50	ns
t_r	Rise Time	$R_{GS} = 15\Omega$		450	ns
$t_{d(off)}$	Turn-Off Delay Time			100	ns
t_f	Fall Time			200	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 18A$ $V_{DD} = 80V$		30	nC

Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse width limited by T_J.

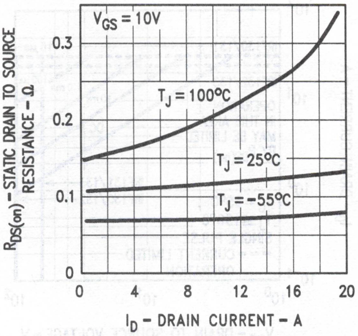
Note 3: Switching time measurements performed on LEM TR-58 test equipment.

Typical Performance Characteristics



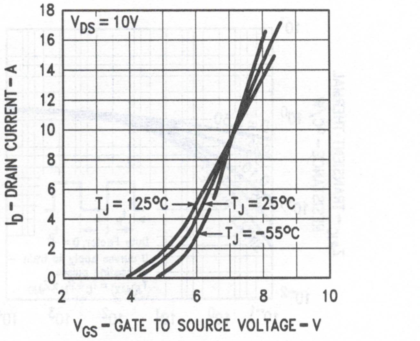
TL/G/10040-A4

FIGURE 1. Output Characteristics



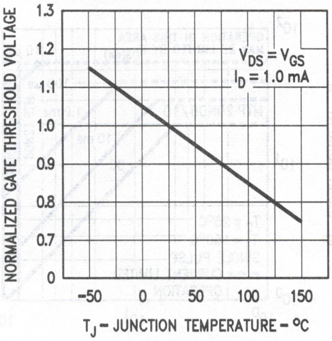
TL/G/10040-A5

FIGURE 2. Static Drain to Source Resistance vs Drain Current



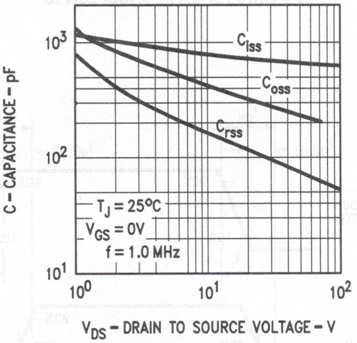
TL/G/10040-A6

FIGURE 3. Transfer Characteristics



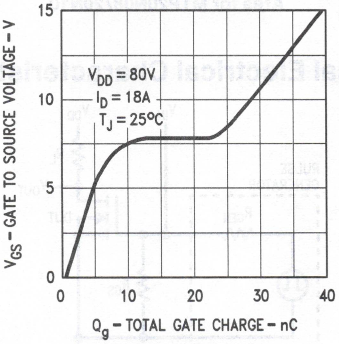
TL/G/10040-A7

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040-A8

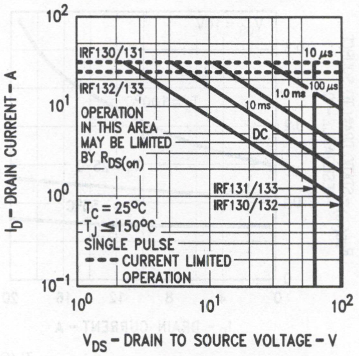
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040-A9

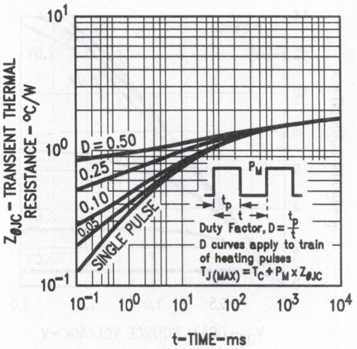
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



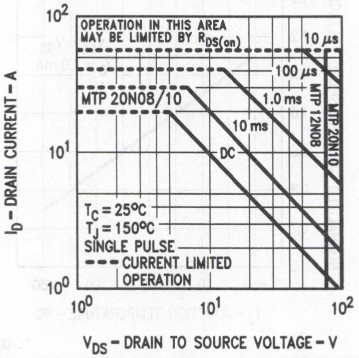
TL/G/10040-B0

FIGURE 7. Forward Biased Safe Operating Area for IRF130–133 and IRF530–533



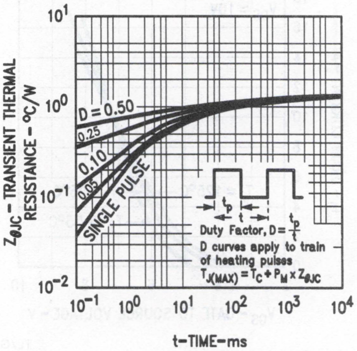
TL/G/10040-B1

FIGURE 8. Transient Thermal Resistance vs Time for IRF130–133 and IRF530–533



TL/G/10040-B2

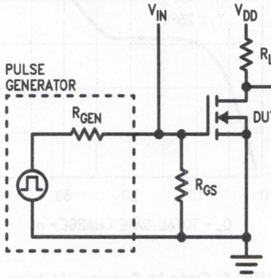
FIGURE 9. Forward Biased Safe Operating Area for MTP20N08/20N10



TL/G/10040-B3

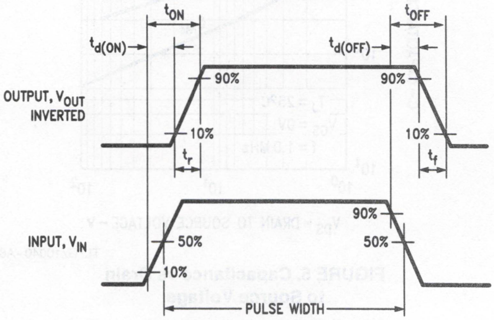
FIGURE 10. Transient Thermal Resistance vs Time for MTP20N08/20N10

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
PULSE GENERATOR
R_{GEN}
DUT
R_{GS}

TL/G/10040-B4

FIGURE 11. Switching Test Circuit

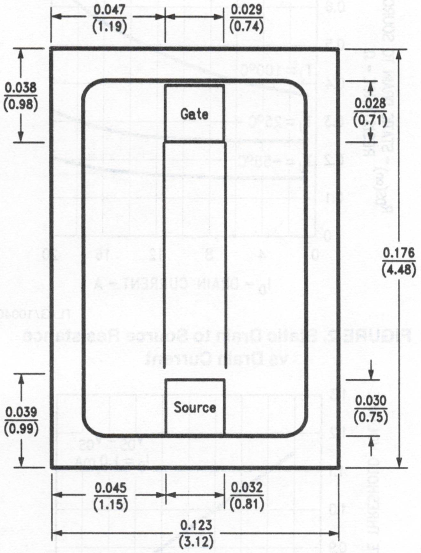

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10040-B5

FIGURE 12. Switching Waveforms

National Semiconductor

Process C2
N-Channel Power MOSFET



TL/G/10040-B6

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF230	IRF630
IRF231	IRF631
IRF232	IRF632
IRF233	IRF633
	MTP12N18
	MTP12N20

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

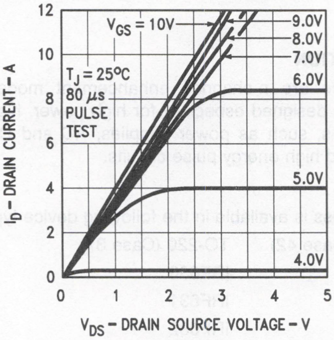
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	200		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 5A$		0.4	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 5A$	3.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ $f = 1$ MHz		800	pF
C_{oss}	Output Capacitance			450	pF
C_{rss}	Reverse Transfer			150	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 25V$; $I_D = 6A$ $V_{GS} = 10V$; $R_{GEN} = 15\Omega$		50	ns
t_r	Rise Time	$R_{GS} = 15\Omega$		250	ns
$t_{d(off)}$	Turn-Off Delay Time			100	ns
t_f	Fall Time			120	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 12A$ $V_{DD} = 120V$		30	nC

Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse width limited by T_J.

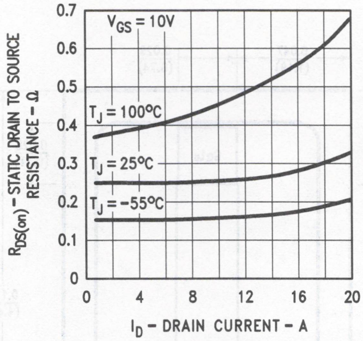
Note 3: Switching time measurements performed on LEM TR-58 test equipment.

Typical Performance Characteristics



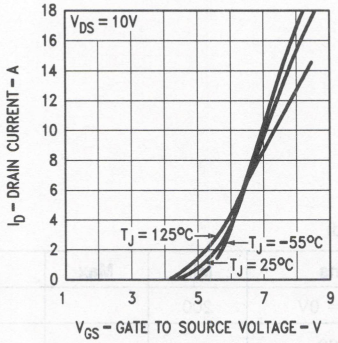
TL/G/10040–B7

FIGURE 1. Output Characteristics



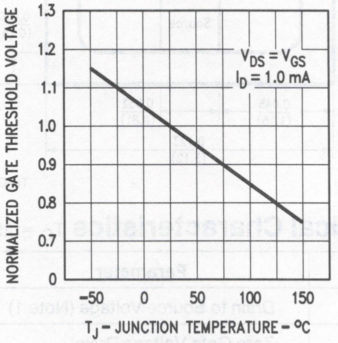
TL/G/10040–B8

FIGURE 2. Static Drain to Source Resistance vs Drain Current



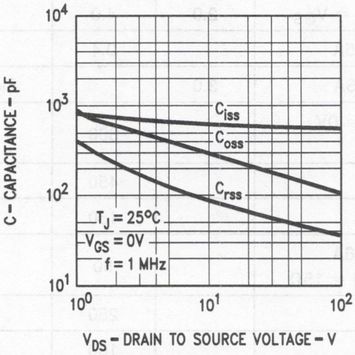
TL/G/10040–B9

FIGURE 3. Transfer Characteristics



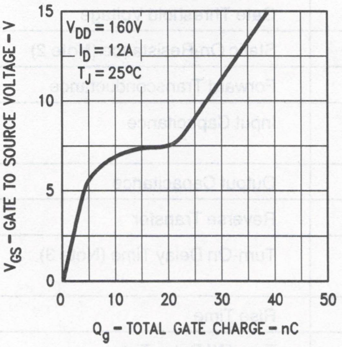
TL/G/10040–C0

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10040–C1

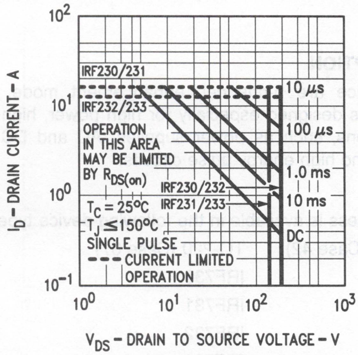
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10040–C2

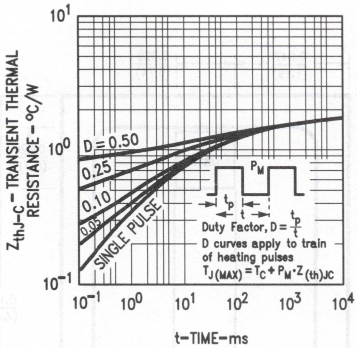
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



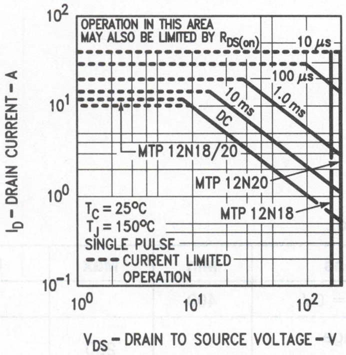
TL/G/10040-C3

FIGURE 7. Forward Biased Safe Operating Area for IRF230–233 and IRF630–633



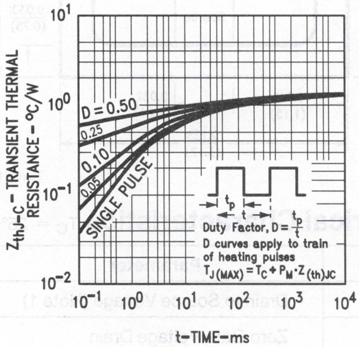
TL/G/10040-C4

FIGURE 8. Transient Thermal Resistance vs Time for IRF230–233 and IRF630–633



TL/G/10040-C5

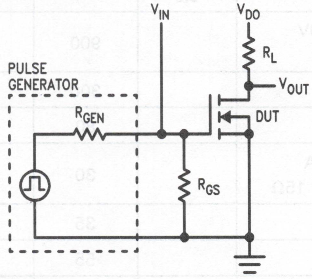
FIGURE 9. Forward Biased Safe Operating Area for MTP12N18/12N20



TL/G/10040-C6

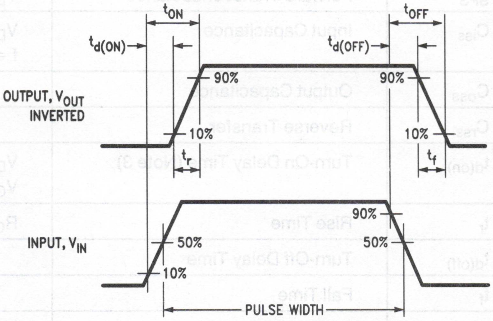
FIGURE 10. Transient Thermal Resistance vs Time for MTP12N18/12N20

Typical Electrical Characteristics


V_IN
V_DO
R_L
V_OUT
DUT
PULSE GENERATOR
R_GEN
R_GS

TL/G/10040-C7

FIGURE 11. Switching Test Circuit

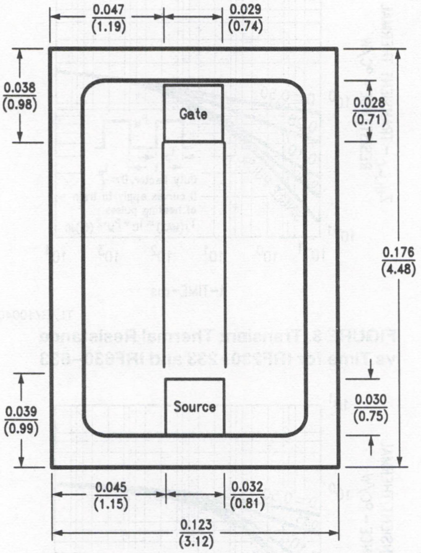

t_ON
t_OFF
t_d(ON)
t_d(OFF)
OUTPUT, V_OUT INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_IN
90%
50%
50%
10%
PULSE WIDTH

TL/G/10040-C8

FIGURE 12. Switching Waveforms

National Semiconductor

Process C3
N-Channel Power MOSFET



TL/G/10040-C9

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF330	IRF730
IRF331	IRF731
IRF332	IRF732
IRF333	IRF733
	MTP5N35
	MTP5N40

Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	400		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	µA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 3A$		1.0	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 3A$	3.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		900	pF
C_{oss}	Output Capacitance			300	pF
C_{rss}	Reverse Transfer			80	pF
$t_{d(on)}$	Turn-On Delay Time (Note 3)	$V_{DD} = 175V$; $I_D = 3A$ $V_{GS} = 10V$; $R_{GEN} = 15\Omega$		30	ns
t_r	Rise Time	$R_{GS} = 15\Omega$		35	ns
$t_{d(off)}$	Turn-Off Delay Time			55	ns
t_f	Fall Time			35	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 7A$ $V_{DD} = 180V$		30	nC

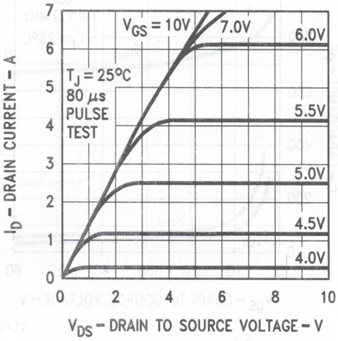
Note 1: $T_J = +25°C$ to $+150°C$.

Note 2: Pulse test: Pulse Width ≤ 80 µs, Duty Cycle ≤ 1%.

Note 3: Switching time measurements performed on LEM TR-58 test equipment.

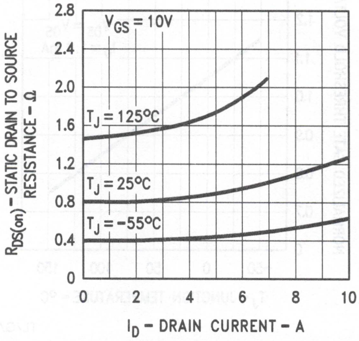
Typical Performance Characteristics

Figures 4–6 for IRF332/333/732/733 only.



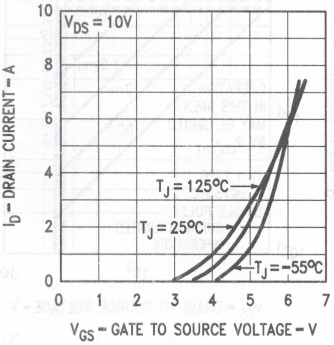
TL/G/10040–D0

FIGURE 1. Output Characteristics



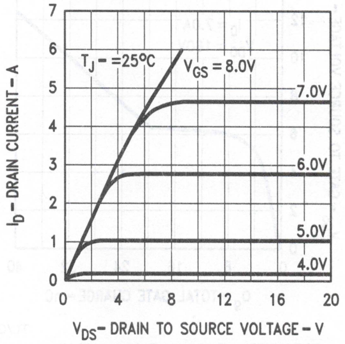
TL/G/10040–D1

FIGURE 2. Static Drain to Source Resistance vs Drain Current



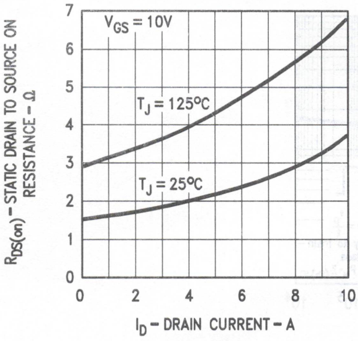
TL/G/10040–D2

FIGURE 3. Transfer Characteristics



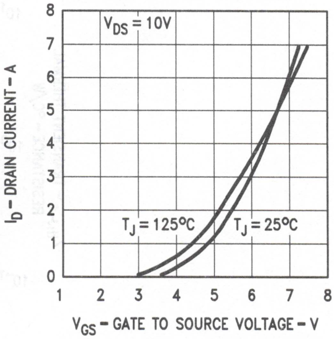
TL/G/10040–D3

FIGURE 4. Output Characteristics



TL/G/10040–D4

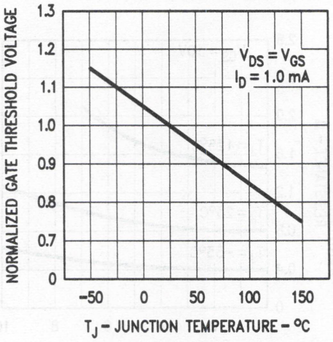
FIGURE 5. Static Drain to Source On-Resistance vs Drain Current



TL/G/10040–D5

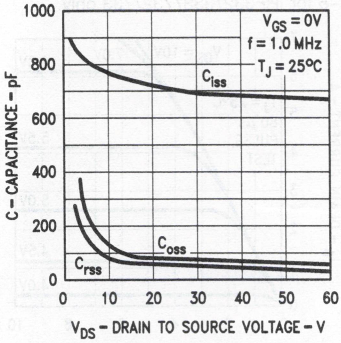
FIGURE 6. Transfer Characteristics

Typical Performance Characteristics (Continued)



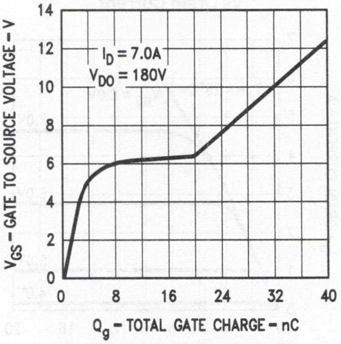
TL/G/10040-D6

FIGURE 7. Temperature Variation of Gate to Source Threshold Voltage



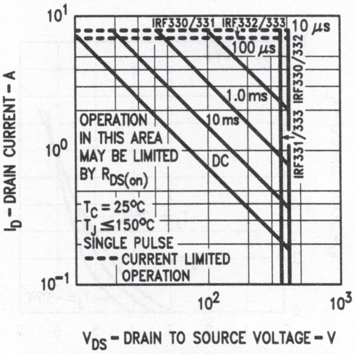
TL/G/10040-D7

FIGURE 8. Capacitance vs Drain to Source Voltage



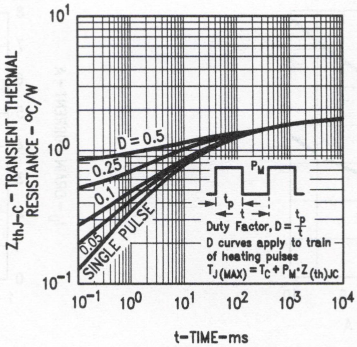
TL/G/10040-D8

FIGURE 9. Gate to Source Voltage vs Total Gate Charge



TL/G/10040-D9

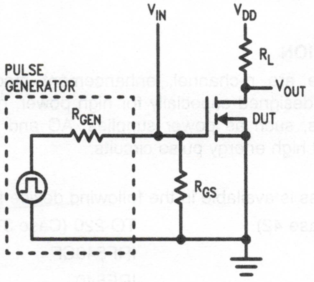
FIGURE 10. Forward Biased Safe Operating Area



TL/G/10040-E0

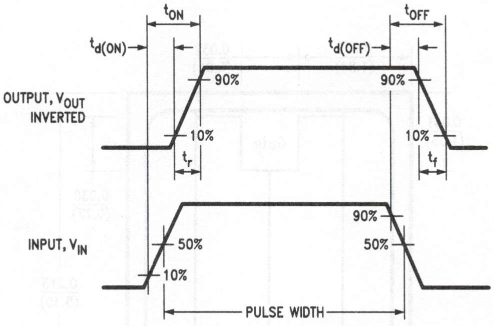
FIGURE 11. Transient Thermal Resistance

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
PULSE GENERATOR
V_{OUT}
R_{GEN}
DUT
R_{GS}

TL/G/10040-E1

FIGURE 12. Switching Test Circuit

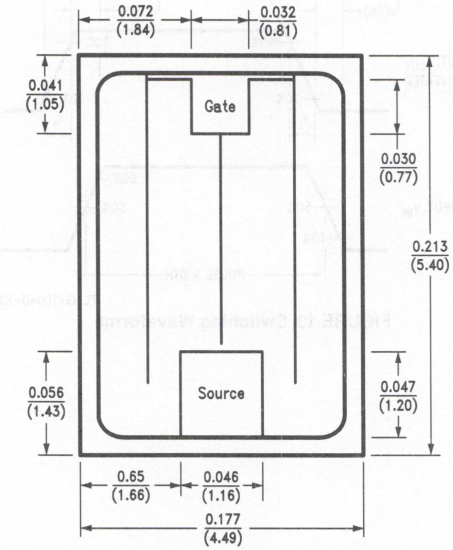

t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10040-E2

FIGURE 13. Switching Waveforms

National Semiconductor

Process E1
N-Channel Power MOSFET



TL/G/10041–1

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF140	IRF540CF
IRF141	IRF540
IRF142	IRF541
IRF143	IRF542
	IRF543

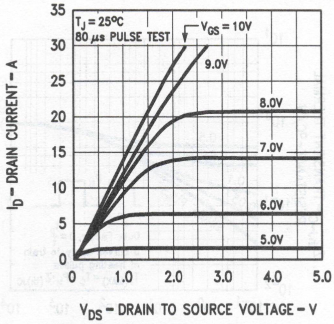
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	100		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 15A$		0.085	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 15A$	6.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		1600	pF
C_{oss}	Output Capacitance			800	pF
C_{rss}	Reverse Transfer			300	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 45V$; $I_D = 15A$ $V_{GS} = 10V$; $R_{GEN} = 4.7\Omega$		60	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		450	ns
$t_{d(off)}$	Turn-Off Delay Time			150	ns
t_f	Fall Time			200	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 34A$ $V_{DD} = 35V$		60	nC

Note 1: T_J = +25°C to +150°C.

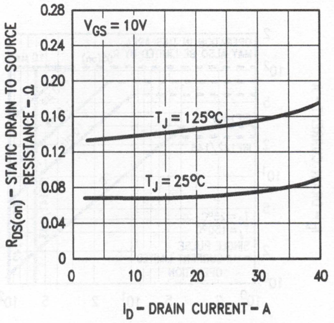
Note 2: Pulse Width limited by T_J.

Typical Performance Characteristics



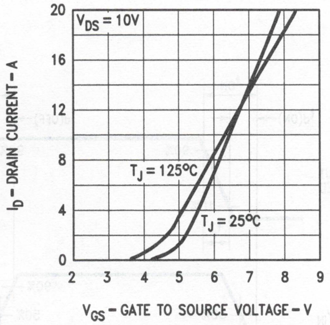
TL/G/10041–2

FIGURE 1. Output Characteristics



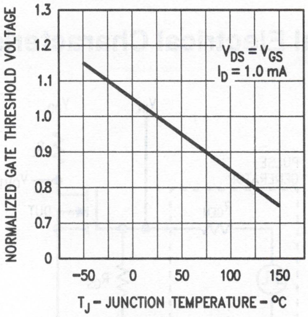
TL/G/10041–3

FIGURE 2. Static Drain to Source Resistance vs Drain Current



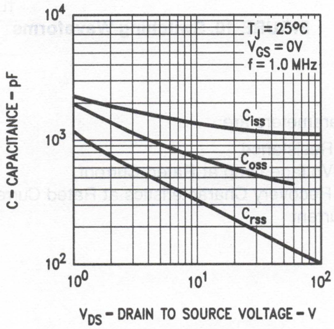
TL/G/10041–4

FIGURE 3. Transfer Characteristics



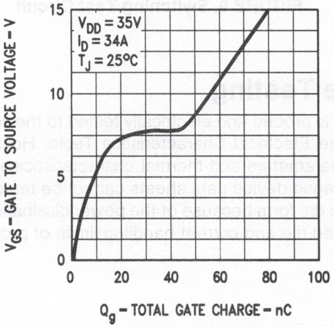
TL/G/10041–5

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041–6

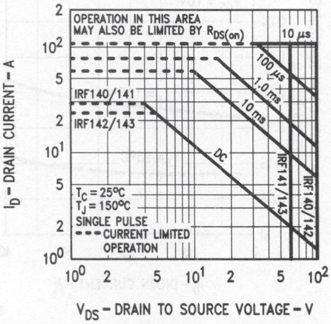
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041–7

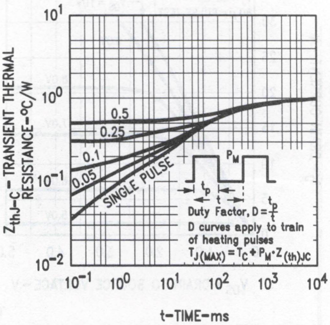
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041–8

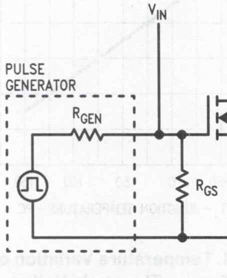
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041–9

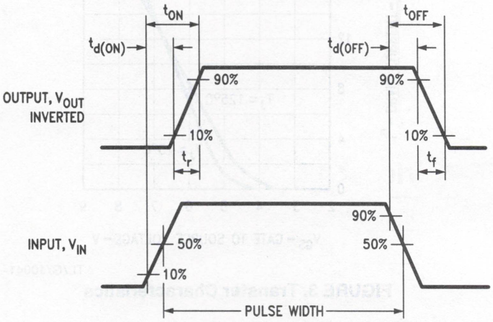
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE
GENERATOR
R_{GEN}
R_{GS}

TL/G/10041–10

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT}
INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10041–11

FIGURE 10. Switching Waveforms

Probe Testing

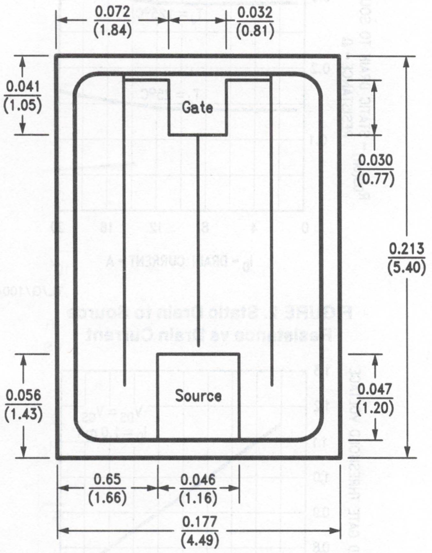
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process E2
N-Channel Power MOSFET



TL/G/10041-12

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF240	IRF640CF
IRF241	IRF640
IRF242	IRF641
IRF243	IRF642
	IRF643

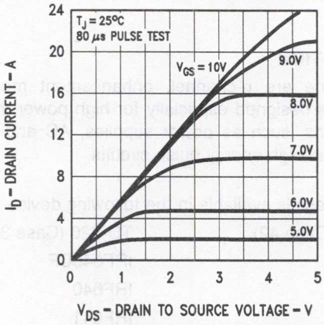
Electrical Characteristics T_C = 25°C (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	I_D = 250 μA; V_{GS} = 0V	200		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage V_{GS} = 0V		250	μA
I_{GSS}	Gate Leakage Current	V_{DS} = ±20V; V_{DS} = 0V		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	I_D = 250 μA; V_{DS} = V_{GS}	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	V_{GS} = 10V; I_D = 10A		0.18	Ω
g_{FS}	Forward Transconductance	V_{DS} = 10V; I_D = 10A	6.0		Siemens
C_{iss}	Input Capacitance	V_{DS} = 25V; V_{GS} = 0V f = 1 MHz		1600	pF
C_{oss}	Output Capacitance			750	pF
C_{rss}	Reverse Transfer			300	pF
$t_{d(on)}$	Turn-On Delay Time	V_{DD} = 75V; I_D = 10A V_{GS} = 10V; R_{GEN} = 4.7Ω		60	ns
t_r	Rise Time	R_{GS} = 4.7Ω		300	ns
$t_{d(off)}$	Turn-Off Delay Time			200	ns
t_f	Fall Time			150	ns
Q_g	Total Gate Charge	V_{GS} = 10V; I_D = 22A V_{DD} = 120V		60	nC

Note 1: T_J = +25°C to +150°C.

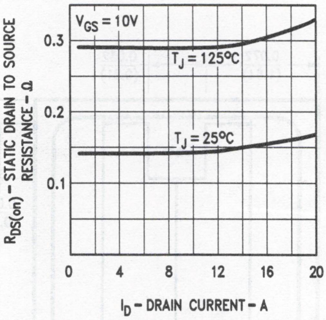
Note 2: Pulse Width limited by T_J.

Typical Performance Characteristics



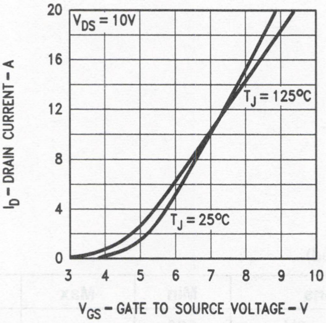
TL/G/10041-13

FIGURE 1. Output Characteristics



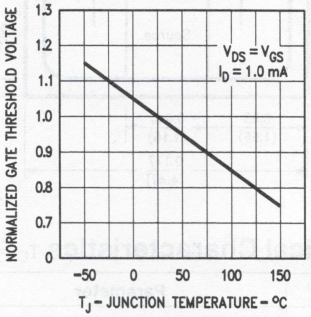
TL/G/10041-14

FIGURE 2. Static Drain to Source Resistance vs Drain Current



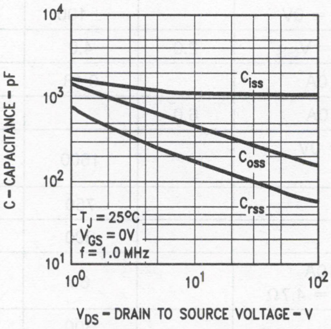
TL/G/10041-15

FIGURE 3. Transfer Characteristics



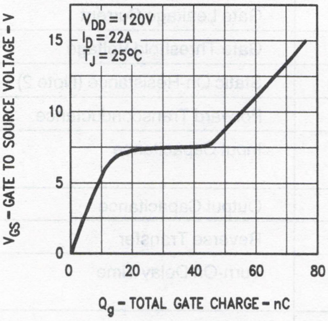
TL/G/10041-16

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041-17

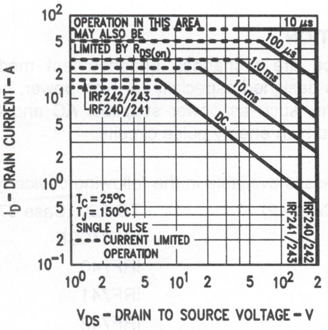
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041-18

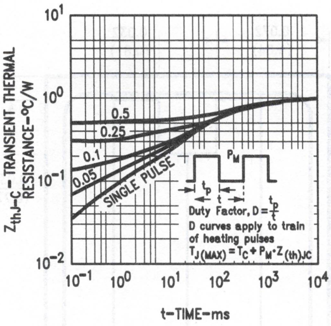
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041-19

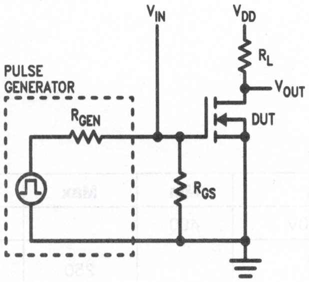
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041-20

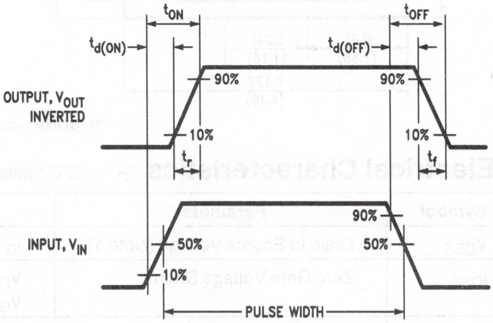
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
PULSE GENERATOR
R_{GEN}
DUT
R_{GS}

TL/G/10041-21

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10041-22

FIGURE 10. Switching Waveforms

Probe Testing

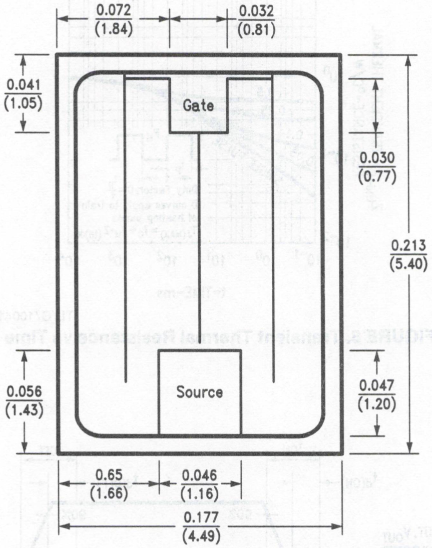
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process E3
N-Channel Power MOSFET



TL/G/10041-23

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF340	IRF740CF
IRF341	IRF740
IRF342	IRF741
IRF343	IRF742
	IRF743

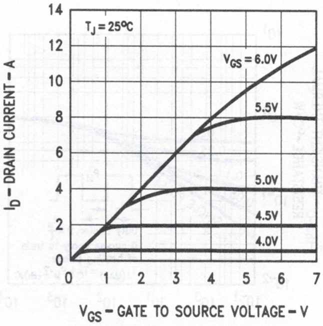
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	400		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 5A$		0.55	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 5A$	4.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		1600	pF
C_{oss}	Output Capacitance			450	pF
C_{rss}	Reverse Transfer			150	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 175V$; $I_D = 5A$ $V_{GS} = 10V$; $R_{GEN} = 4.7\Omega$		35	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		15	ns
$t_{d(off)}$	Turn-Off Delay Time			90	ns
t_f	Fall Time			35	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 12A$ $V_{DD} = 400V$		60	nC

Note 1: $T_J = +25°C$ to $+150°C$.

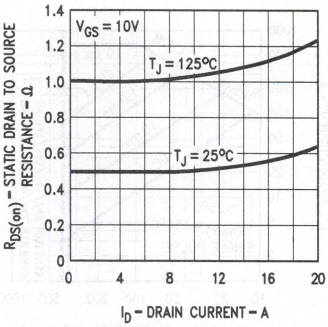
Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



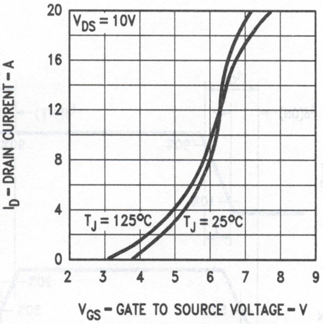
TL/G/10041–24

FIGURE 1. Output Characteristics



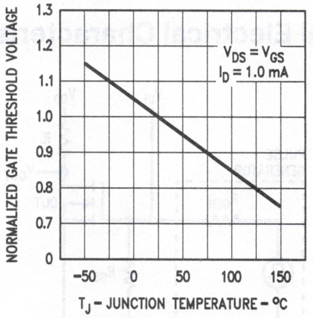
TL/G/10041–25

FIGURE 2. Static Drain to Source Resistance vs Drain Current



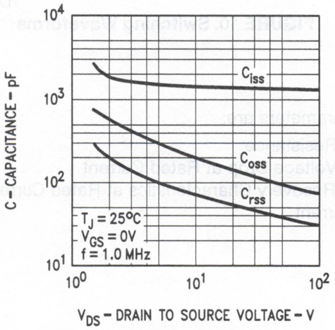
TL/G/10041–26

FIGURE 3. Transfer Characteristics



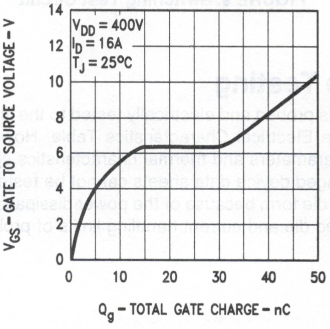
TL/G/10041–27

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041–28

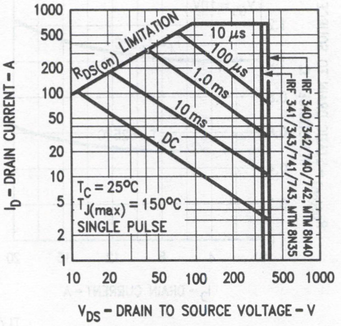
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041–29

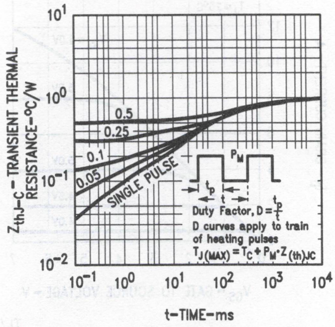
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041–30

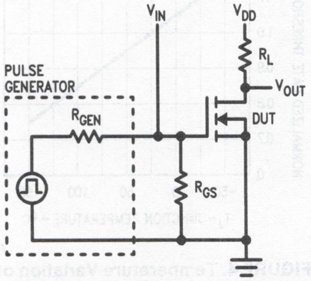
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041–31

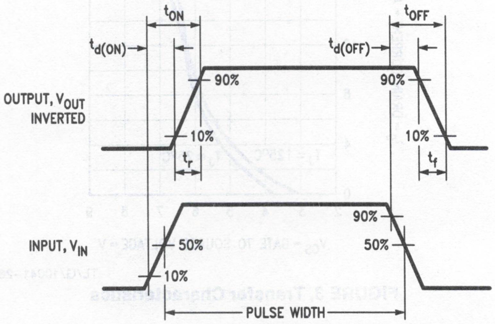
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
PULSE GENERATOR
R_{GEN}
DUT
R_{GS}

TL/G/10041–32

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10041–33

FIGURE 10. Switching Waveforms

Probe Testing

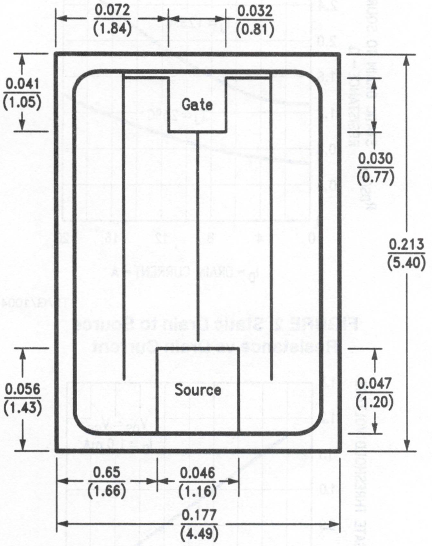
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process E4
N-Channel Power MOSFET



TL/G/10041-34

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-220 (Case 37)
IRF440	IRF840CF
IRF441	IRF840
IRF442	IRF841
IRF443	IRF842
	IRF843

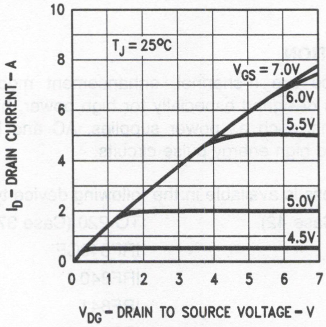
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A; V_{GS} = 0V$	500		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V; V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A; V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V; I_D = 4.0A$		0.85	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V; I_D = 4.0A$	4.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V; V_{GS} = 0V$ $f = 1$ MHz		1600	pF
C_{oss}	Output Capacitance			350	pF
C_{rss}	Reverse Transfer			150	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 220V; I_D = 4A$ $V_{GS} = 10V; R_{GEN} = 4.7\Omega$		35	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		15	ns
$t_{d(off)}$	Turn-Off Delay Time			90	ns
t_f	Fall Time			30	ns
Q_g	Total Gate Charge	$V_{GS} = 10V; I_D = 12A$ $V_{DD} = 400V$		60	nC

Note 1: $T_J = +25°C$ to $+150°C$.

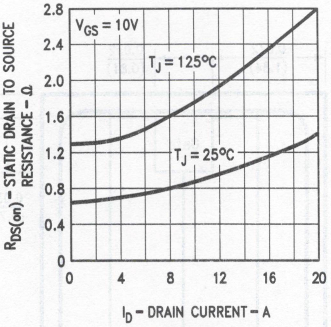
Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



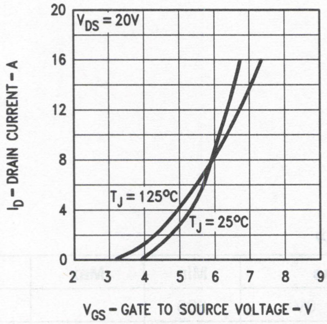
TL/G/10041-35

FIGURE 1. Output Characteristics



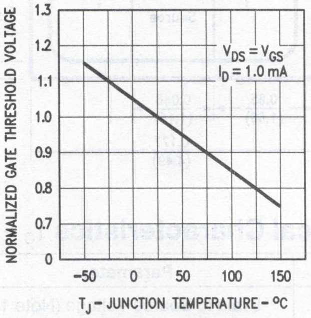
TL/G/10041-36

FIGURE 2. Static Drain to Source Resistance vs Drain Current



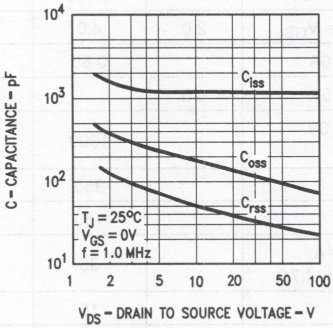
TL/G/10041-37

FIGURE 3. Transfer Characteristics



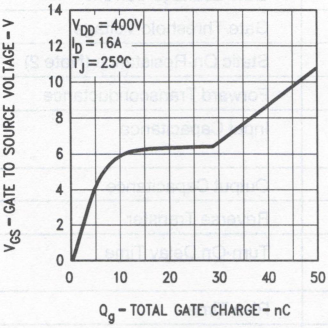
TL/G/10041-38

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041-39

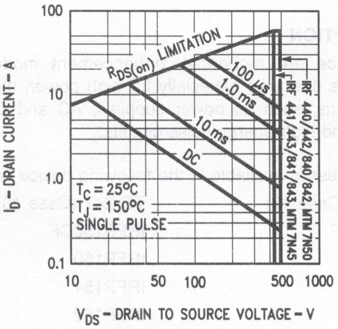
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041-40

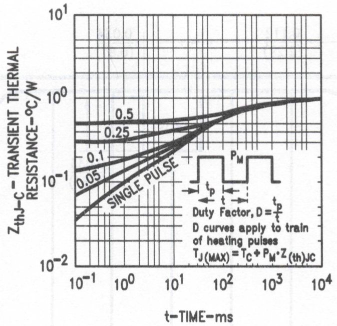
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041–41

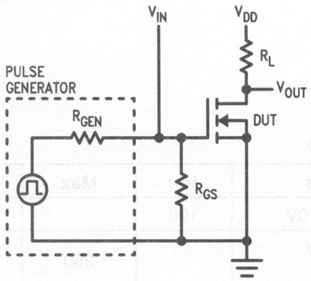
FIGURE 7. Forward Biased Safe Operating Area Curves



TL/G/10041–42

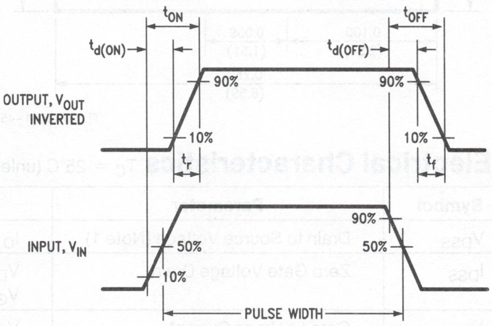
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10041–43

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10041–44

FIGURE 10. Switching Waveforms

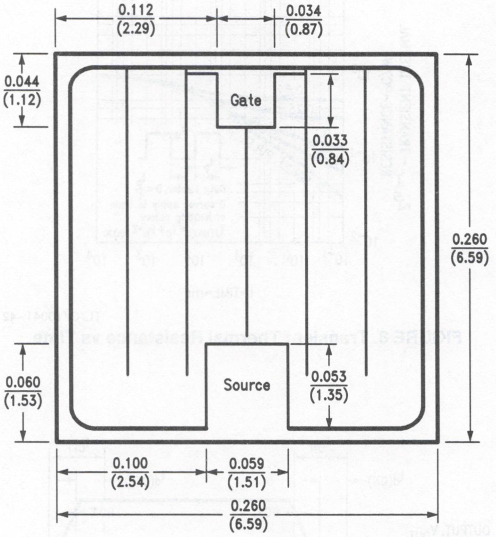
Probe Testing

Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:
Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process F1
N-Channel Power MOSFET



TL/G/10041-45

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 43)	TO-247 (Case 40)
IRF150CF	IRFP150CF
IRF150	IRFP150
IRF151	IRFP151
IRF152	IRFP152
IRF153	IRFP153

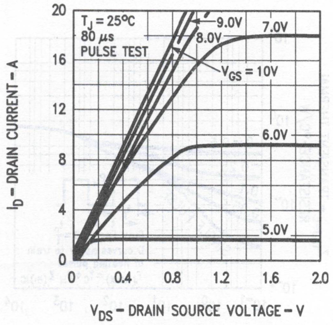
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	100		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 20A$		0.055	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 20A$	9.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ $f = 1$ MHz		3000	pF
C_{oss}	Output Capacitance			1500	pF
C_{rss}	Reverse Transfer			500	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 48V$; $I_D = 20A$ $V_{GS} = 10V$; $R_{GEN} = 4.7\Omega$		75	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		450	ns
$t_{d(off)}$	Turn-Off Delay Time			300	ns
t_f	Fall Time			200	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 50A$ $V_{DD} = 55V$		120	nC

Note 1: $T_J = +25°C$ to $+150°C$.

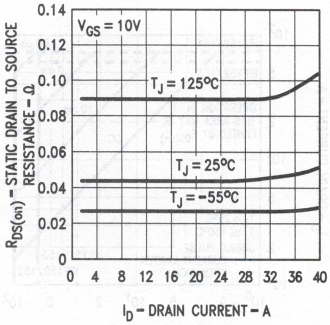
Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



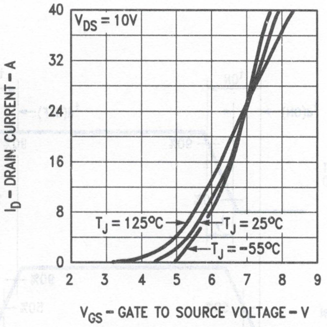
TL/G/10041–46

FIGURE 1. Output Characteristics



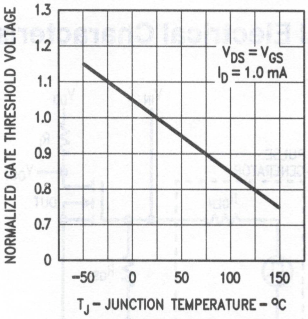
TL/G/10041–47

FIGURE 2. Static Drain to Source Resistance vs Drain Current



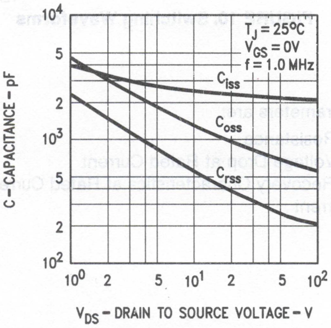
TL/G/10041–48

FIGURE 3. Transfer Characteristics



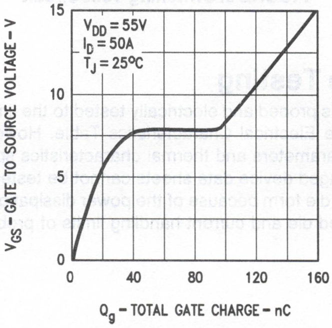
TL/G/10041–49

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041–50

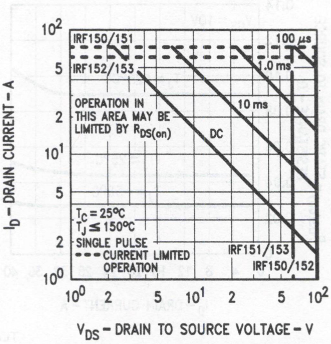
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041–51

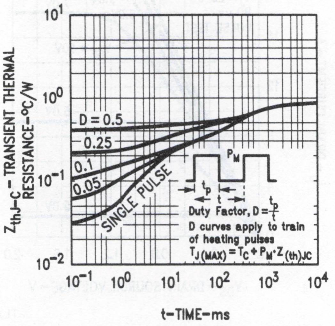
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041–52

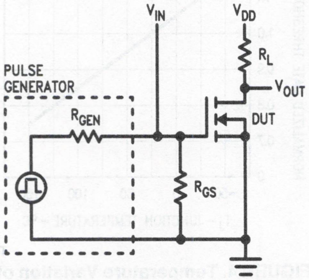
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041–53

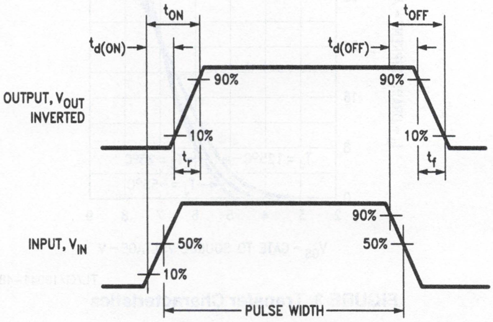
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10041–54

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10041–55

FIGURE 10. Switching Waveforms

Probe Testing

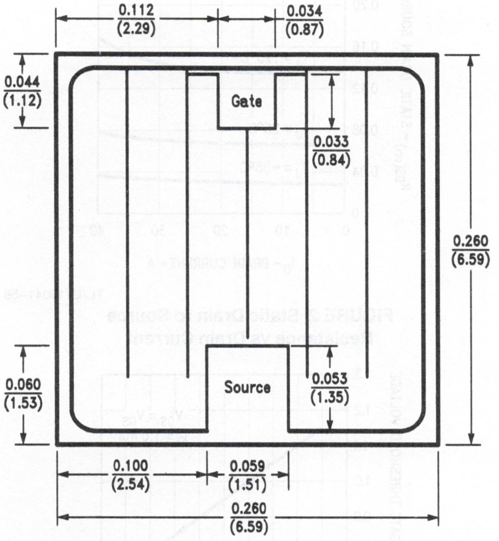
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process F2
N-Channel Power MOSFET



TL/G/10041-56

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 43)	TO-247 (Case 40)
IRF250CF	IRFP250CF
IRF250	IRFP250
IRF251	IRFP251
IRF252	IRFP252
IRF253	IRFP253

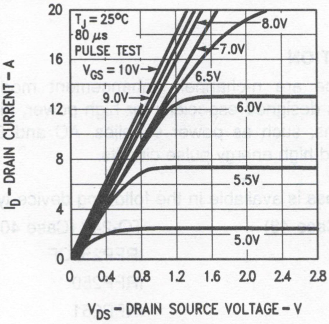
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A; V_{GS} = 0V$	200		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V; V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A; V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V; I_D = 16A$		0.085	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V; I_D = 16A$	8.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V; V_{GS} = 0V$ f = 1 MHz		3000	pF
C_{oss}	Output Capacitance			1200	pF
C_{rss}	Reverse Transfer			500	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 95V; I_D = 16A$ $V_{GS} = 10V; R_{GEN} = 4.7\Omega$		75	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		300	ns
$t_{d(off)}$	Turn-Off Delay Time			275	ns
t_f	Fall Time			150	ns
Q_g	Total Gate Charge	$V_{GS} = 10V; I_D = 38A$ $V_{DD} = 100V$		120	nC

Note 1: $T_J = +25°C$ to $+150°C$.

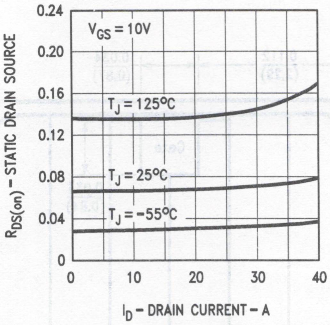
Note 2: Pulse Test: Pulse Width ≤ 80 μs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



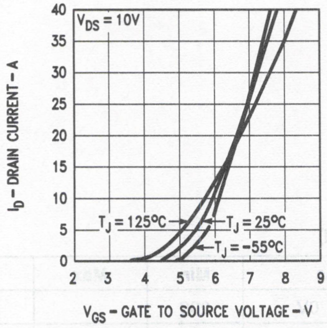
TL/G/10041-57

FIGURE 1. Output Characteristics



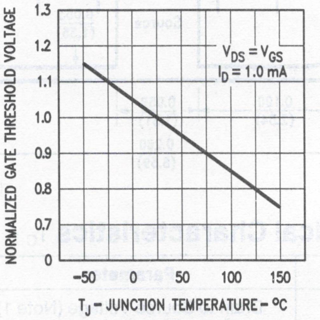
TL/G/10041-58

FIGURE 2. Static Drain to Source Resistance vs Drain Current



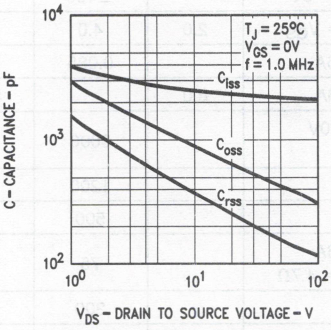
TL/G/10041-59

FIGURE 3. Transfer Characteristics



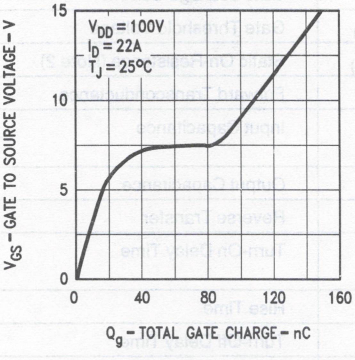
TL/G/10041-60

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041-61

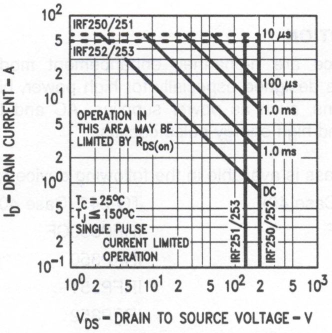
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041-62

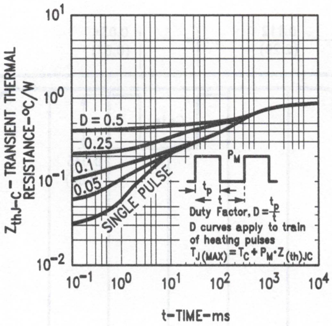
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041-63

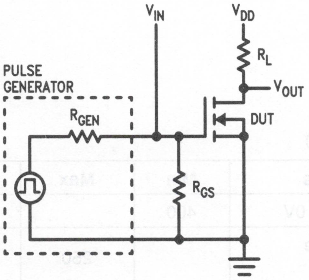
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041-64

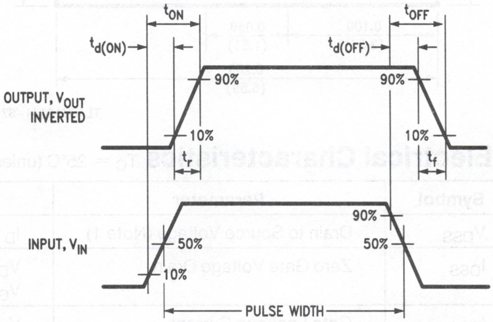
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10041-65

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10041-66

FIGURE 10. Switching Waveforms

Probe Testing

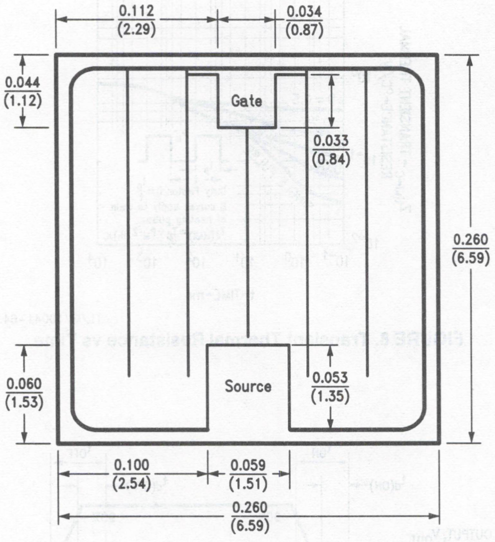
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process F3
N-Channel Power MOSFET



TL/G/10041-67

DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-247 (Case 40)
IRF350CF	IRFP350CF
IRF350	IRFP350
IRF351	IRFP351
IRF352	IRFP352
IRF353	IRFP353

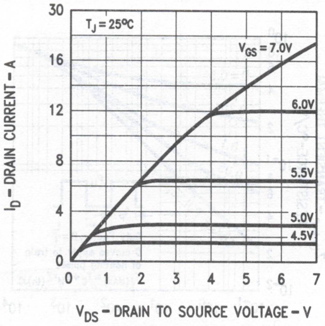
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	400		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 8A$		0.3	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 8A$	8.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		3000	pF
C_{oss}	Output Capacitance			600	pF
C_{rss}	Reverse Transfer			200	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 180V$; $I_D = 8A$ $V_{GS} = 10V$; $R_{GEN} = 4.7\Omega$		35	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		65	ns
$t_{d(off)}$	Turn-Off Delay Time			150	ns
t_f	Fall Time			75	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 16A$ $V_{DD} = 400V$		120	nC

Note 1: $T_J = +25°C$ to $+150°C$.

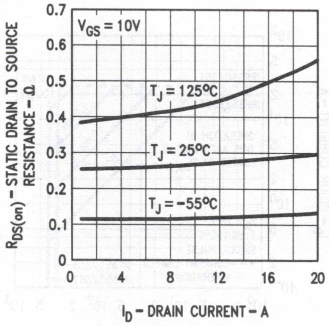
Note 2: Pulse Test: Pulse Width ≤ 80 µs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



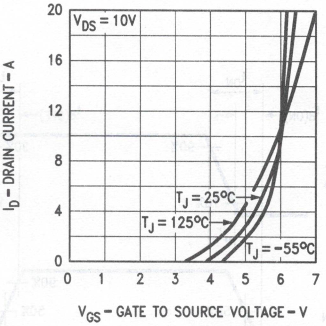
TL/G/10041-68

FIGURE 1. Output Characteristics



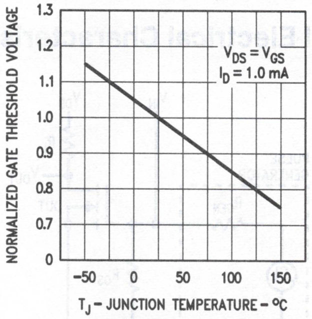
TL/G/10041-69

FIGURE 2. Static Drain to Source Resistance vs Drain Current



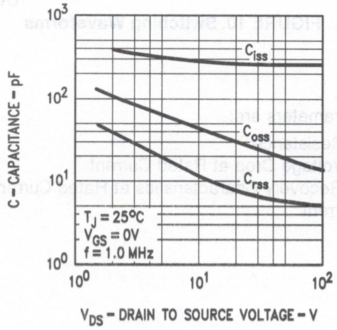
TL/G/10041-70

FIGURE 3. Transfer Characteristics



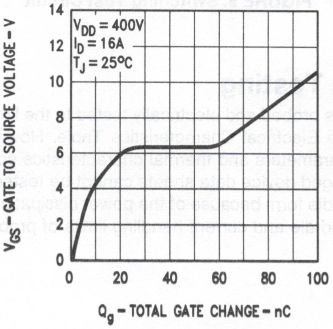
TL/G/10041-71

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041-72

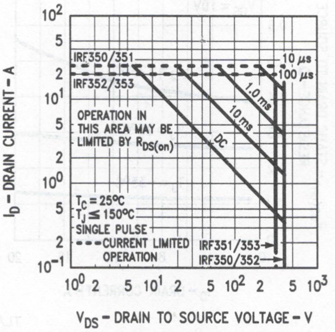
FIGURE 5. Capacitance vs Drain to Source Voltage



TL/G/10041-73

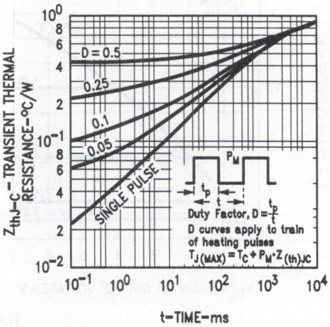
FIGURE 6. Gate to Source Voltage vs Total Gate Charge

Typical Performance Characteristics (Continued)



TL/G/10041-74

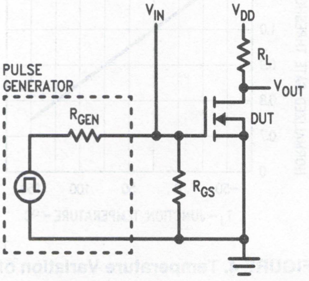
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041-75

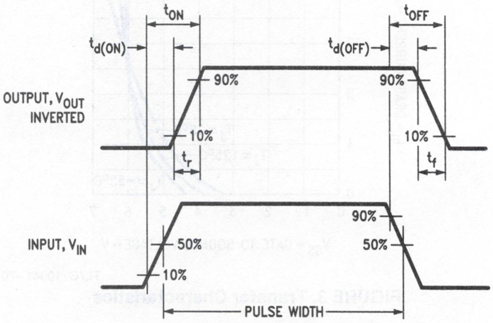
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
PULSE GENERATOR
R_{GEN}
DUT
R_{GS}

TL/G/10041-76

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
OUTPUT, V_{OUT} INVERTED
90%
90%
10%
10%
t_r
t_f
INPUT, V_{IN}
90%
50%
50%
10%
PULSE WIDTH

TL/G/10041-77

FIGURE 10. Switching Waveforms

Probe Testing

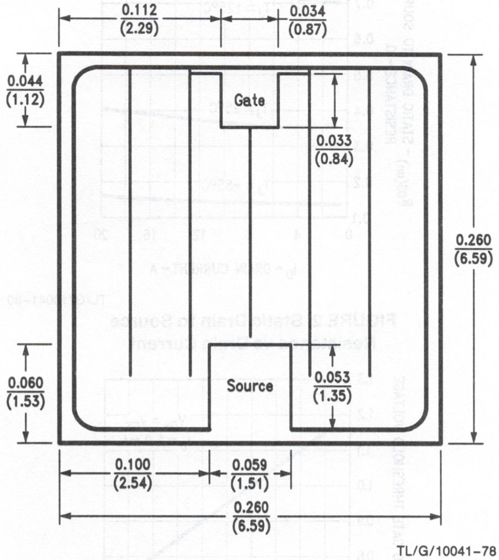
Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

National Semiconductor

Process F4
N-Channel Power MOSFET



DESCRIPTION

These dice are n-channel, enhancement mode, power MOSFETs designed especially for high power, high speed applications, such as power supplies, AC and DC motor control and high energy pulse circuits.

This process is available in the following device types:

TO-204 (Case 42)	TO-247 (Case 40)
IRF450CF	IRFP450CF
IRF450	IRFP450
IRF451	IRFP451
IRF452	IRFP452
IRF453	IRFP453

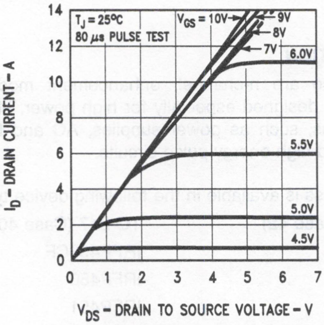
Electrical Characteristics $T_C = 25°C$ (unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Max	Units
V_{DSS}	Drain to Source Voltage (Note 1)	$I_D = 250\ \mu A$; $V_{GS} = 0V$	500		V
I_{DSS}	Zero Gate Voltage Drain	V_{DS} = Rated Voltage $V_{GS} = 0V$		250	μA
I_{GSS}	Gate Leakage Current	$V_{DS} = \pm 20V$; $V_{DS} = 0V$		±100	nA
$V_{GS(TH)}$	Gate Threshold Voltage	$I_D = 250\ \mu A$; $V_{DS} = V_{GS}$	2.0	4.0	V
$R_{DS(ON)}$	Static On-Resistance (Note 2)	$V_{GS} = 10V$; $I_D = 7.0A$		0.4	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V$; $I_D = 7.0A$	6.0		Siemens
C_{iss}	Input Capacitance	$V_{DS} = 25V$; $V_{GS} = 0V$ f = 1 MHz		3000	pF
C_{oss}	Output Capacitance			600	pF
C_{rss}	Reverse Transfer			200	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 210V$; $I_D = 7.0A$ $V_{GS} = 10V$; $R_{GEN} = 4.7\Omega$		35	ns
t_r	Rise Time	$R_{GS} = 4.7\Omega$		50	ns
$t_{d(off)}$	Turn-Off Delay Time			150	ns
t_f	Fall Time			70	ns
Q_g	Total Gate Charge	$V_{GS} = 10V$; $I_D = 16A$ $V_{DD} = 400V$		120	nC

Note 1: $T_J = +25°C$ to $+150°C$.

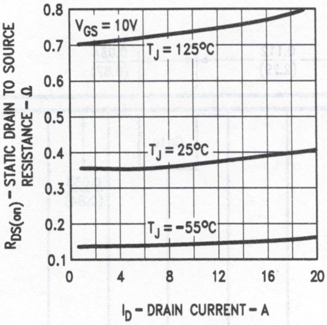
Note 2: Pulse Test: Pulse Width ≤ 20 μs, Duty Cycle ≤ 1%.

Typical Performance Characteristics



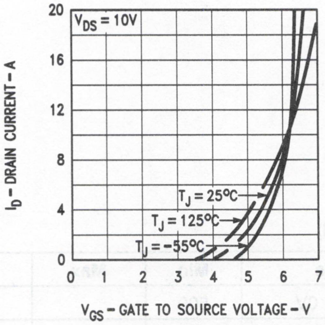
TL/G/10041-79

FIGURE 1. Output Characteristics



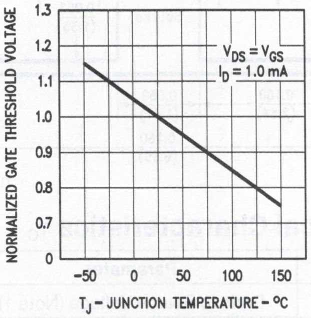
TL/G/10041-80

FIGURE 2. Static Drain to Source Resistance vs Drain Current



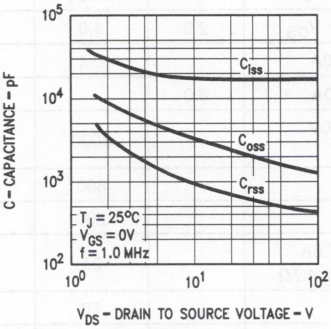
TL/G/10041-81

FIGURE 3. Transfer Characteristics



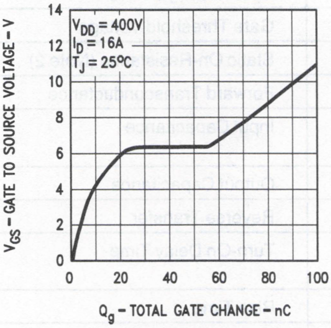
TL/G/10041-82

FIGURE 4. Temperature Variation of Gate to Source Threshold Voltage



TL/G/10041-83

FIGURE 5. Capacitance vs Drain to Source Voltage

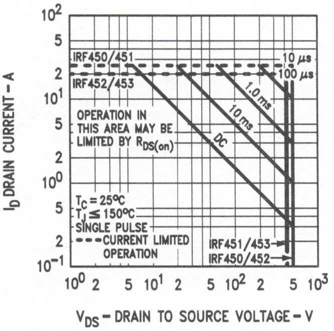


TL/G/10041-84

FIGURE 6. Gate to Source Voltage vs Total Gate Charge

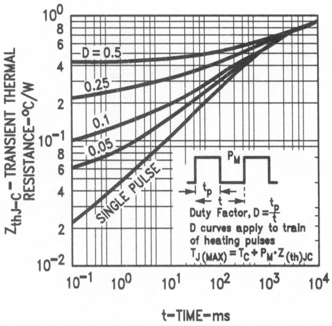
Process F4

Typical Performance Characteristics (Continued)



TL/G/10041-85

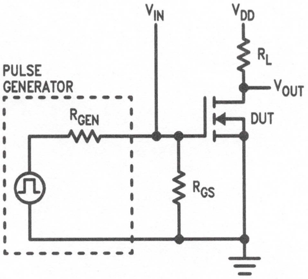
FIGURE 7. Forward Biased Safe Operating Area



TL/G/10041-86

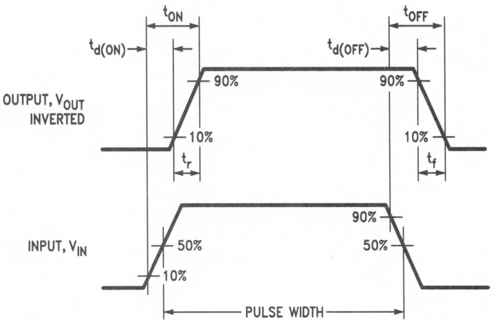
FIGURE 8. Transient Thermal Resistance vs Time

Typical Electrical Characteristics


V_{IN}
V_{DD}
R_L
V_{OUT}
DUT
PULSE GENERATOR
R_{GEN}
R_{GS}

TL/G/10041-87

FIGURE 9. Switching Test Circuit


t_{ON}
t_{OFF}
$t_{d(ON)}$
$t_{d(OFF)}$
90%
90%
OUTPUT, V_{OUT} INVERTED
10%
10%
t_r
t_f
90%
INPUT, V_{IN}
50%
50%
10%
PULSE WIDTH

TL/G/10041-88

FIGURE 10. Switching Waveforms

Probe Testing

Each die is probed and electrically tested to the limits specified in the Electrical Characteristics Table. However, high current parameters and thermal characteristics specified in the packaged device data sheets cannot be tested or guaranteed in die form because of the power dissipation limits of unmounted die and current handling limits of probe tips.

These parameters are:

Thermal Resistance
Forward Voltage Drop at Rated Current
Reverse Recovery Characteristics at Rated Current
Surge Current

Section 12

Appendices, Packaging and Ordering Information

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AN-557 Optimizing the Ultra-Fast POWERPlanar™ Rectifier Diode for Switching Power Supplies 12-31
AN-558 Introduction to Power MOSFETs and Their Applications 12-37
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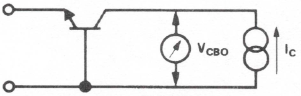
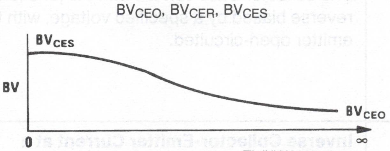
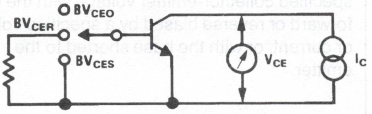
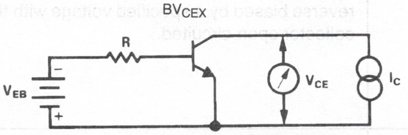
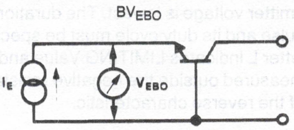
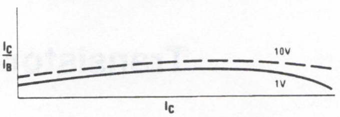
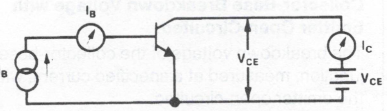
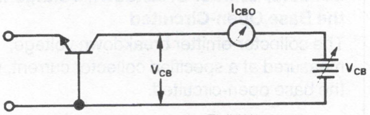
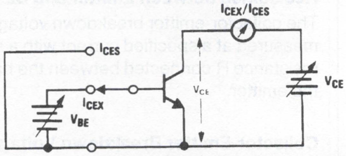
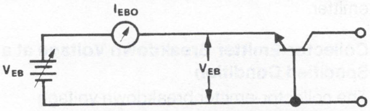
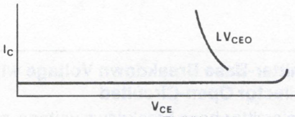
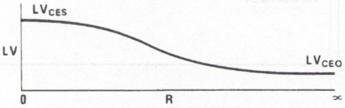
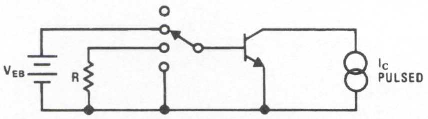
Transistor Glossary of Symbols

DC PARAMETERS

BV_{CBO}	**Collector-Base Breakdown Voltage with Emitter Open-Circuited** The breakdown voltage of the collector-base junction, measured at a specified current, with the emitter open-circuited.	 TL/XX/0125-1
BV_{CEO}	**Collector-Emitter Breakdown Voltage with the Base Open-Circuited** The collector-emitter breakdown voltage, measured at a specified collector current, with the base open-circuited.	 TL/XX/0125-2
BV_{CER}	**Collector-Emitter Breakdown Voltage with Resistance between Emitter and Base** The collector-emitter breakdown voltage measured at a specified current with a specified resistance R connected between the base and the emitter.	 TL/XX/0125-3
BV_{CES}	**Collector-Emitter Breakdown Voltage with Base Shorted to Emitter** The collector-emitter breakdown, measured at a specified current, with the base shorted to the emitter.	
BV_{CEX}	**Collector-Emitter Breakdown Voltage at a Specified Condition** The collector-emitter breakdown voltage measured at a specified current with the base-emitter junction forward or reverse biased by a specified voltage or current.	 TL/XX/0125-4
BV_{EBO}	**Emitter-Base Breakdown Voltage with Collector Open-Circuited** The emitter-base breakdown voltage, measured at a specified current, with the collector open-circuited.	 TL/XX/0125-5

DC PARAMETERS (Continued)

h_{FE}	**Common-Emitter DC Current Gain** The ratio of DC collector current to DC base current measured at a specified collector-emitter voltage and a specified collector current.	h_{FE} – BETA  TL/XX/0125-6 $\alpha = \frac{\beta}{\beta + 1}\ \beta = \frac{\alpha}{1 - \alpha}$  TL/XX/0125-7
I_{CBO}	**Inverse Collector-Base Current** The collector-base current with the junction reverse biased by a specified voltage, with the emitter open-circuited.	 TL/XX/0125-8 $I_{CEO} = (\beta + 1)\ I_{CBO}$
I_{CEX}, I_{CES}	**Inverse Collector-Emitter Current at a Specified Condition** The collector-emitter current measured at a specified collector-emitter voltage with the base forward or reverse biased by a specified voltage or current, or with the base shorted to the emitter.	 TL/XX/0125-9
I_{EBO}	**Inverse Emitter-Base Current** The emitter-base current with the junction reverse biased by a specified voltage with the collector open-circuited.	 TL/XX/0125-10
LV_{CEO}, LV_{CER}, LV_{CES}, LV_{CEX}, or V_{CEO} (sust) V_{CER} (sust) V_{CES} (sust) V_{CEX} (sust)	**Pulsed Limiting Breakdown Voltages** These are similar to the corresponding, above defined, BV parameters but are measured at a specified high current point where collector-emitter voltage is lowest. The duration of the pulse and its duty cycle must be specified. The letter L indicates LIMITING Value and is measured outside the negative resistance zone of the reverse characteristic.	LV_{CEO}, LV_{CER}, LV_{CES}, LV_{CEX}  TL/XX/0125-11  TL/XX/0125-12  TL/XX/0125-13

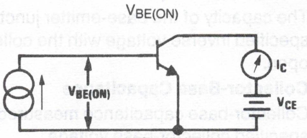
DC PARAMETERS (Continued)

$V_{BE\ (ON)}$

Unsaturated Base-Emitter Voltage

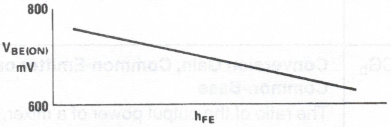
The base-emitter voltage measured in the common-emitter connection at a specified collector to emitter voltage and specified collector current.

$V_{BE(ON)}$



TL/XX/0125-14

$\Delta V_{BE(ON)} \cong \Delta t \cong 1.8\ mV/°C - 2.4\ mV/°C$



TL/XX/0125-15

$V_{BE(SAT)}$

Base-Emitter Saturation Voltage

The base-emitter voltage measured in the common-emitter connection at a specified collector and base saturation currents.

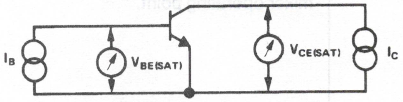
$V_{CE(SAT)}$

Collector-Emitter Saturation Voltage

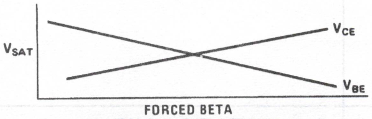
The collector-emitter voltage measured in the common-emitter connection at specified collector and base saturation currents.

$V_{BE(SAT)}$, $V_{CE(SAT)}$

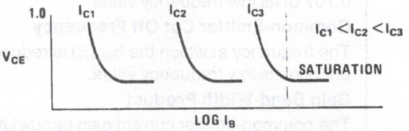
$\beta_{CKT} = \frac{I_C}{I_B}$



TL/XX/0125-16



TL/XX/0125-17



TL/XX/0125-18

V_{RT}

V_{PT}

Reach Through Voltage

Punch Through Voltage

The collector-base voltage above which an increase of applied voltage can be measured in the emitter-base open circuit.

SMALL SIGNAL PARAMETERS

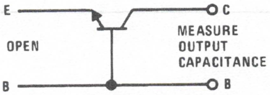
C_{ob}

Common-Base Output Capacitance

The common-base output capacitance with input ac open.

CAPACITANCE

1) C_{ob}



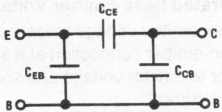
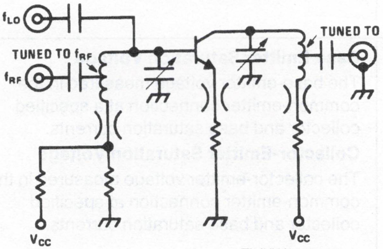
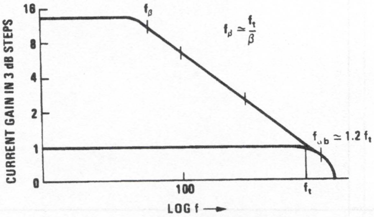
TL/XX/0125-19

C_{re}

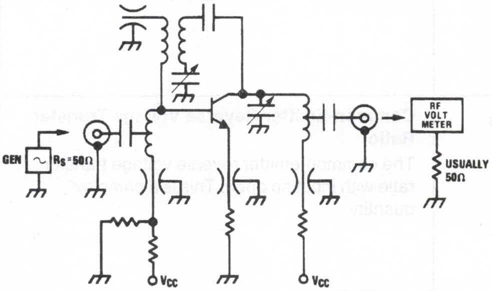
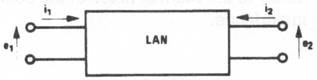
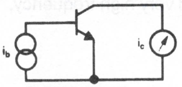
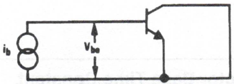
Common-Emitter Reverse Transfer Capacitance

This parameter is the imaginary port of Y_{re}. When $I_C = 0$, C_{re} is identical to C_{CB}.

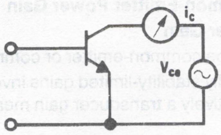
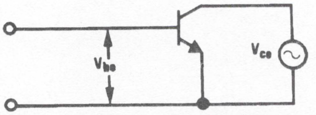
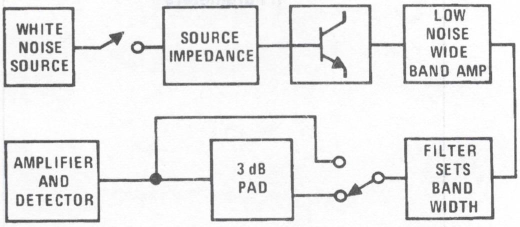
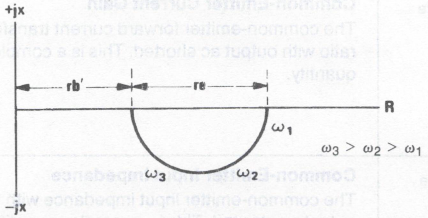
SMALL SIGNAL PARAMETERS (Continued)

C_{te}, C_{ib}, C_{EB} C_{CB}	**Base-Emitter Capacitance** The capacity of the base-emitter junction at a specified inverse voltage with the collector open. **Collector-Base Capacitance** Collector-base capacitance measured at some specified collector-base voltage.	 TL/XX/0125-20 $C_{ob} = C_{CB} + \frac{C_{CE}\,C_{EB}}{C_{CE} + C_{EB}} = C_{CB} + C_{CE}$ 2) C_{CB} $C_{CB} = C_{ob}$ (WITH EMITTER GUARDED)
CG_e, CG_b	**Conversion Gain, Common-Emitter or Common-Base** The ratio of the output power of a mixer, at one specified frequency, to its input power, at another specified frequency. This parameter is a function of oscillator injection voltage and the mixer operating point.	CONVERSION GAIN 1) SPECIFY I_C, V_{CE} 2) f_{RF}, f_{IF} LO LEVEL, CIRCUIT  f_{LO} TUNED TO f_{RF} f_{RF} TUNED TO I_F V_{CC} V_{CC} TL/XX/0125-21 $f_{IF} = f_{RF} - f_{LO}$
$f_{\alpha b}$, $f_{h_{fb}}$ f_β, $f_{h_{fe}}$ f_t	**Common-Base Cut Off Frequency** The frequency at which the h_{fb} (α) is reduced to 0.707 of its low frequency value. **Common-Emitter Cut Off Frequency** The frequency at which the h_{fe} (β) is reduced to 0.707 of its low frequency value. **Gain Band-Width Product** The common-emitter current gain bandwidth product in the frequency range where the current gain is falling at approximately 6 db/octave. **Transition Frequency** The frequency at which the h_{fe} (β) is equal to 1.0. This is a device figure of merit that is often specified at a V_{CE} and I_c.	$f_{\alpha b}$, f_β, f_t  TL/XX/0125-22
f_{MAX}	**Maximum Frequency of Oscillation** This parameter is a device figure of merit that is calculated from ft and rb'Cc.	$f_{MAX} = \frac{\text{MAX FREQUENCY OF OSCILLATION}}{\text{FREQUENCY AT WHICH MAG} = 1}$ $f_{MAX} = \sqrt{\frac{f_t}{8\pi\ \text{rb Cc}}} = f\sqrt{PG}$

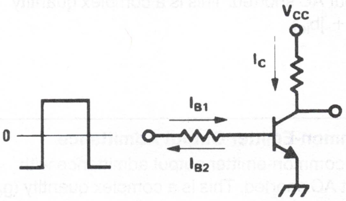
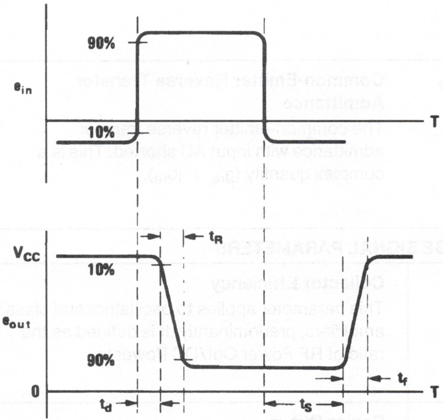
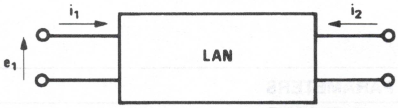
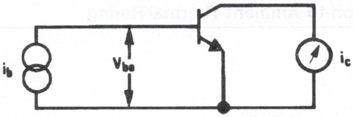
SMALL SIGNAL PARAMETERS (Continued)

GP_e PG	**Common-Emitter Power Gain** **Power Gain** Can be common-emitter or common-base. Usually stability-limited gains involved, thus are effectively a transducer gain measurement.	POWER GAIN, TRANSCONDUCER GAIN 1) SPECIFY I_C, V_{CE} 2) fo, $\beta\omega$, CIRCUIT, NEUTRALIZED?  GEN $R_S = 50\Omega$ RF VOLT METER USUALLY 50Ω V_{CC} V_{CC} TL/XX/0125-23
G_{TE}	**Common-Emitter Transducer Gain** A test fixture must be specified.	$G_{TE} = \frac{\text{POWER DELIVERED TO THE LOAD}}{\text{POWER AVAILABLE FROM THE SOURCE}}$
GMA	**Stability Limited Gain or Gain Maximum Available** This parameter is a device figure of merit and must be calculated from the two port "y" parameters.	$\text{GMA} = 10\ \text{LOG}\left[\frac{\lvert Y_{fe}\rvert}{\lvert Y_{re}\rvert}\left(k - \sqrt{K^2 - 1}\right)\right]$ NOT DEFINED FOR $K < 1$
	h Parameters	h-PARAMETERS  TL/XX/0125-24 WHERE e_1, i_1, e_2, i_2 ARE SMALL SIGNAL VOLTAGES AND CURRENTS THE h − (HYBRID) PARAMETERS ARE DEFINED BY $e_1 = h_{11}\, i_1 + h_{12}\, e_2$ $i_2 = h_{21}\, i_1 + h_{22}\, e_2$ AND FOR COMMON EMITTER OPERATION THESE E Q BECOME $e_1 = h_{ie}\, i_1 + h_{re}\, e_2$ $i_2 = h_{fe}\, i_1 + h_{oe}\, e_2$
h_{fe}	**Common-Emitter Current Gain** The common-emitter forward current transfer ratio with output ac shorted. This is a complex quantity.	h − PARAMETERS-COMMON EMITTER  $h_{fe} = \frac{I_C}{i_b}\Big\vert_{V_{ce} = 0}$ TL/XX/0125-25
h_{ie}	**Common-Emitter Input Impedance** The common-emitter input impedance with the output ac shorted. This is a complex quantity.	 $h_{ie} = \frac{V_{be}}{i_b}\Big\vert_{V_{ce} = 0}$ TL/XX/0125-26

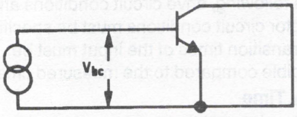
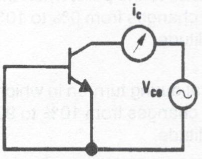
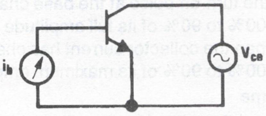
SMALL SIGNAL PARAMETERS (Continued)

h_{oe}	**Common-Emitter Output Admittance** The common-emitter output admittance with the input ac open. This is a complex quantity.	 $h_{oe} = \frac{i_e}{V_{ce}}\Big\|_{i_b = 0}$ TL/XX/0125-27
h_{re}	**Common-Emitter Reverse Voltage Transfer Ratio** The common-emitter reverse voltage transfer ratio with input ac open. This is a complex quantity.	 $h_{re} = \frac{V_{be}}{V_{ce}}\Big\|_{i_b = 0}$ TL/XX/0125-28
MAG	**Maximum Available Gain** Device figure of merit that must be calculated from the two port "y" parameters.	$\text{MAG} = 10\ \text{LOG}\ \frac{\|Y_{21}\|^2}{4\ \text{Re}\ (Y_{11})\ \text{Re}\ (Y_{22})}$
MSG	**Maximum Stable Gain** This parameter is a device figure of merit that is calculated from the two port "y" parameters.	$\text{MSG} = 10\ \text{LOG}\ \frac{\|Y_{fe}\|}{\|Y_{re}\|}$
NF	**Noise Figure** Noise figure = 10 $\log_{10}F$, where F is the ratio of total output noise power to the output power due solely to the thermal noise of the source impedance.	NOISE FIGURE MUST SPECIFY 1) V_{CE}, I_C 2) R_S, f_o, PBW  WHITE NOISE SOURCE SOURCE IMPEDANCE LOW NOISE WIDE BAND AMP AMPLIFIER AND DETECTOR 3 dB PAD FILTER SETS BAND WIDTH TL/XX/0125-29
r_{bb}', r_b'	**Base <<Spreading>> Resistance** Equivalent to the real part of h_{ie} at some specified very high frequency.	r_b' MEASUREMENT  +jx rb' re R ω_1 ω_2 ω_3 $\omega_3 > \omega_2 > \omega_1$ −jx TL/XX/0125-30
rb'Cc	**Collector Base Time Constant** This parameter is a device figure of merit and is measured in a specified test circuit.	$r_b'\ C_c$ = COLLECTOR BASE TIME CONSTANT SPECIFY — I_C, V_{CE}, FREQUENCY

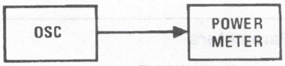
SMALL SIGNAL PARAMETERS (Continued)

t_d t_{ON} t_r t_s t_{OFF} t_f	**Common-Emitter Switching Parameters** In the following, drive circuit conditions and collector circuit conditions must be specified. The transition times of the input must be negligible compared to the measured times. **Delay Time** The time interval during turn-on from the point when the input pulse at the base reaches 10% of its full amplitude to the point when the collector pulse changes from 0% to 10% of its maximum amplitude. **Rise Time** The time interval during turn-on in which the collector pulse changes from 10% to 90% of its maximum amplitude. **Storage Time** The time interval during turn-off from the point when the turn-off pulse at the base changes from 100% to 90% of its full amplitude to the time when the collector current has changed from 100% to 90% of its maximum amplitude. **Fall Time** The time interval during turn-off in which the collector pulse decreases from 90% to 10% of its maximum amplitude.	SWITCHING PARAMETERS  V_{CC} I_C I_{B1} I_{B2} 0 TL/XX/0125-31 $T_{ON} = t_d + t_r$ $T_{OFF} = t_s + t_f$  90% e_{in} 10% T t_R V_{CC} 10% e_{out} 90% 0 t_d t_s t_f T TL/XX/0125-32
	Y Parameters	Y PARAMETERS  i₁ i₂ LAN e₁ e₂ TL/XX/0125-33 Y PARAMETERS ARE DEFINED BY $i_1 = y_{11} e_1 + y_{12} e_2$ $i_2 = y_{21} e_1 + y_{22} e_2$ OR IN COMMON EMITTER NOTATION $i_1 = y_{ie} e_1 + y_{re} e_2$ $i_2 = y_{fe} e_1 + y_{oe} e_2$
Y_{fe}	**Common-Emitter Forward Transfer Admittance** The common-emitter forward transfer admittance with output AC shorted. This is a complex quantity ($g_{fe} + jb_{fe}$).	 $Y_{fe} = \frac{i_c}{V_{be}}\Big\vert_{V_{ce} \cong 0}$ TL/XX/0125-34

SMALL SIGNAL PARAMETERS (Continued)

Y_{ie}	**Common-Emitter Input Admittance** The common-emitter input admittance with output AC shorted. This is a complex quantity ($g_{ie} + jb_{ie}$).	Y PARAMETERS—COMMON EMITTER  $Y_{ie} = \frac{i_b}{V_{be}}\Big\|_{V_{ce} = 0}$ TL/XX/0125-35
Y_{oe}	**Common-Emitter Output Admittance** The common-emitter output admittance with input AC shorted. This is a complex quantity ($g_{oe} + jb_{oe}$).	 $Y_{oe} = \frac{I_c}{V_{ce}}\Big\|_{V_{be}} = 0$ TL/XX/0125-36
Y_{re}	**Common-Emitter Reverse Transfer Admittance** The common-emitter reverse transfer admittance with input AC shorted. This is a complex quantity ($g_{re} + jb_{re}$).	 $Y_{ro} = \frac{i_b}{V_{ce}}\Big\|_{V_{be} = 0}$ TL/XX/0125-37

LARGE SIGNAL PARAMETERS

η	**Collector Efficiency** This parameter applies to oscillators and class C amplifiers, predominantly. It is defined as the ratio of RF Power Out/DC Power In.	η − COLLECTOR EFFICIENCY $\eta = \frac{P_o\,(RF)}{P_{IN(DC)}} = \frac{vi}{I_C \times V_{CE}}$
P_o	**Power Out** This parameter applies to oscillators. The units are Watts and a test circuit must be specified.	 TL/XX/0125-38 SPECIFY − I_C V_{CE} UNDER QUIESCENT CONDITIONS − f_o, R_{LOAD}

THERMAL PARAMETERS

R_{TH}	**Internal Junction-to-Case Thermal Resistance** The rated increase of junction temperature with respect to the case temperature per unit of dissipated power. It is called Thermal Resistance with infinite heat sink.	
θ_{JC}	**Junction-to-Case Thermal Rating**	
θ_{JA}	**Junction-to-Ambient Thermal Rating**	

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Diode and Rectifier Glossary of Symbols and Terms

BV Breakdown Voltage: *Figure 1* shows the reverse characteristic of a typical silicon diode. Breakdown voltage is generally the reverse voltage at a point beyond the "knee" of the reverse characteristic. In *Figure 1*, the breakdown voltage is specified at a reverse current of I_{R2}.

C Capacitance: Diode capacitance is measured at a specified reverse voltage using an AC signal of specified frequency. When capacitance is measured at $V_R = 0$, this is sometimes denoted by the symbol C_o.

C_c Case Capacitance: This is that part of a diode's total capacitance which is attributable to the diode package.

f_o Series Resonant Frequency: The frequency of oscillation of the tuned circuit formed by the capacitance and inherent series inductance of the diode.

I_F Continuous Forward Current (Rating): The maximum direct current that can be safely passed through a diode in the forward direction.

I_F Forward Current: The direct current passing through a diode in the forward direction.

I_f Forward Current: The forward current passing through a diode operated under switching conditions. See *Figure 3*.

I_f Peak Repetitive Forward Current: The maximum value of the peak point of a current that can safely be passed through a diode in the forward direction. This is a continuous (i.e. repetitive) rating.

$I_{f_{surge}}$ Peak Forward Surge Current: The maximum value of the peak point of a single cycle of current that can safely be passed through a diode in the forward direction. This is not a continuous rating.

I_{FSM} Peak Forward Surge Current: This rating is the same as $I_{f(surge)}$ but is more generally applied to rectifiers.

I_O Average Rectified Current: The average value of the forward current passing through a diode; as a rating, the maximum value of such current that can safely be passed.

I_R Reverse Current: The leakage current which flows in the reverse direction through a diode when a reverse voltage is applied to the diode. Referring to *Figure 1*, I_R is usually measured at a specified reverse voltage at a point below the "knee" on the reverse characteristic.

I_r Reverse Current: The peak value of reverse curent which occurs immediately after switch-off. The value of I_r is limited by the circuit, which determines that rate at which stored charge can be dissipated. See *Figure 3*.

I_{rr} Reverse Current: The steady value of reverse current at equilibrium after switch-off. See *Figure 3*.

I_{RAV} Average Reverse Current: The average reverse current which flows when AC voltage is applied across a diode.

I_{RM} Reverse Recovery Current: The peak value of reverse current which flows immediately after switching applied voltage from the forward to the reverse direction. I_{RM} is the same as I_r, generally used for rectifiers.

I_{RX} Reverse Current: I_{RX} is the symbol used to denote the reverse current of a single diode in an array at a time when all other diodes in the array are passing forward current. It is a measure of cross-talk between diodes.

I_Z Zener Current: The reverse current which flows in a zener diode at a point beyond the knee in the reverse characteristic. See *Figure 2*.

$I_{Z_{surge}}$ Maximum Zener Surge Current: The maximum value of the peak point of a single cycle of current that can safely be passed through a zener diode in the reverse direction. This is not a continuous rating.

I_{ZM} Maximum Zener Current: The maximum value of direct current that can safely be passed through a zener diode in the reverse direction.

L_S Series Inductance: Series inductance that is inherent in the construction of a diode, normally measured between two specified points on the diode leads.

N_D Noise Density: A measurement of the noise generated within a zener diode, both due to zener breakdown and internal resistance. Noise density, measured in microvolts rms per square root cycle, can be used to calculate rms noise over any frequency range.

NF Noise Figure: This is a ratio used to measure the noise generated within a diode. The ratio used is total output noise compared to that part of output noise due to input noise This ratio, when multiplied by 10 $\log_{10}$, is known as noise figure and is measured in decibels (dB).

Q Figure of Merit: Generally used as a measure of the "quality" of varactor diodes, Q, the figure of merit, is defined as the ratio of energy stored to energy dissipated.

Q_S Stored Charge: The charge stored in a diode when passing current in the forward direction. Stored charge is usually measured by switching the diode off and measuring the area of the I versus t curve from switchoff to equilibrium. See *Figure 3*.

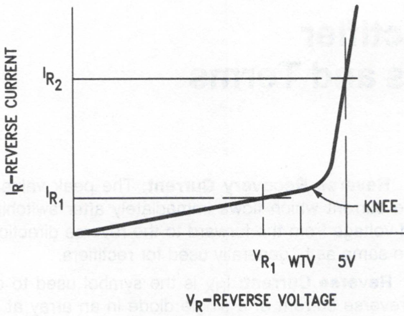
R_D Dynamic Resistance: Small signal resistance of a diode operating in the reverse direction determined by the small signal or AC values of reverse current and reverse voltage. This parameter is of particular importance in varactor diodes.

r_{diff} Differential Resistance: Small signal resistance of a diode operating in the forward direction determined by the small signal or AC values of forward current and forward voltage.

RE Rectification Efficiency: The ratio of DC load voltage to peak RF input voltage to a detector.

Diode and Rectifier Glossary of Symbols and Terms (Continued)

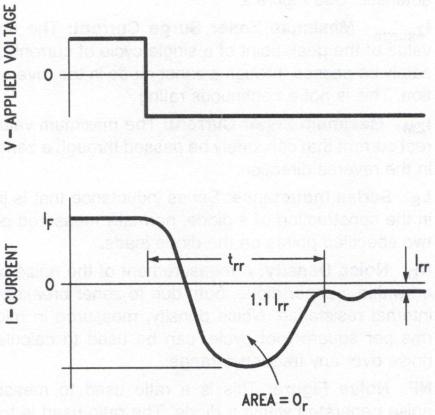
Reverse Characteristic



TL/XX/0122–1

FIGURE 1

Reverse Recovery Characteristic



TL/XX/0122–3

FIGURE 3

R_S Series Resistance: Small signal resistance of a diode operating in the forward direction determined by the small signal or AC values of forward current and forward voltage. Same as r_{diff}.

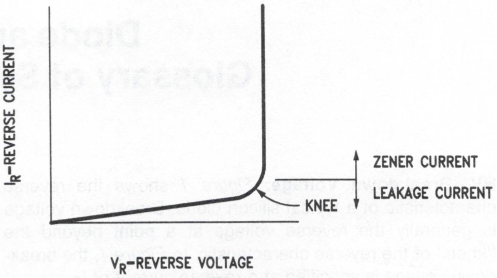
TC Temperature Coefficient: A coefficient which determines the variation of various parameters (e.g. Capacitance, Zener voltage, forward voltage) with temperature. A subscript is often used to denote the parameter to which the temperature coefficient refers.

t_{fr} Forward Recovery Time: The time interval between the point at which a diode is turned on and the point at which the forward voltage comes to within 10% of its equilibrium level. See *Figure 4*.

t_{rr} Reverse Recovery Time: The time interval between the point at which a diode is turned off and the point at which the reverse current comes to within 10% of its equilibrium level. See *Figure 3*.

V_F Forward Voltage: The voltage applied across a diode in the forward direction (anode more positive than cathode).

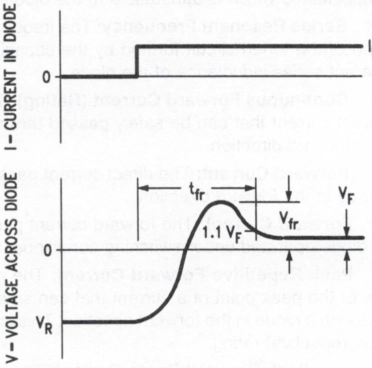
Zener Diode Reverse Characteristic



TL/XX/0122–2

FIGURE 2

Forward Recovery Characteristic



TL/XX/0122–4

FIGURE 4

V_{FAV} Average Forward Voltage: The average value of forward voltage when current is being passed through a diode in the forward direction.

V_{fr} Forward Recovery Voltage: The peak value of forward voltage reached immediately after switch-on. The value of V_{fr} is limited by the circuit in which the diode is operating.

V_{FX} Forward Voltage: V_{FX} is the symbol used to denote the forward voltage of a single diode in an array at a time when the condition of the other diodes in the array is defined. It can be used as a measure of cross-talk between diodes.

V_{PK} Peak Forward Voltage: The peak value of forward voltage reached immediately after switch-on. Same as V_{fr}.

V_R DC Blocking Voltage Rating: The continuous reverse voltage at which a rectifier can be safely operated without going beyond the "knee" in the reverse characteristic *(Figure 1)*.

Diode and Rectifier Glossary of Symbols and Terms (Continued)

V_R Reverse Voltage: The voltage applied across a diode in the reverse direction (anode more negative than cathode).

V_{RRM} Peak Repetitive Reverse Voltage: The maximum value of the peak point of a reverse voltage that can be safely applied to a diode. This is a continuous (i.e. repetitive) rating and includes all repetitive transient voltages.

V_{Rrms} rms Reverse Voltage: The maximum rms value of a reverse voltage that can be safely applied to a diode.

V_{RWM} Working Peak Reverse Voltage: The maximum value of the peak point of a reverse voltage that can be safely applied to a diode. This is not a continuous rating and does not include transient voltages.

V_Z Zener Voltage: The reverse voltage across a zener diode at a point where zener current is flowing. See *Figure 2*.

WIV Working Inverse Voltage: The maximum reverse voltage at which a diode can be operated below the "knee" on the reverse characteristic. See *Figure 1*.

Z_Z Zener Impedance: The small signal impedance of a zener diode operating in the zener region, determined by the small signal or AC values of zener current and zener voltage.

Z_{ZK} Zener Knee Impedance: Zener impedance measured at a defined point on the "knee" of the zener characteristic (See *Figure 2*).

ΔI_R Reverse Current Match: The difference in reverse current between any two diodes measured under the same condition for each.

ΔV_F Forward Voltage Match: The difference in forward voltage between any two diodes measured under the same conditions for each.

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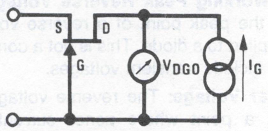
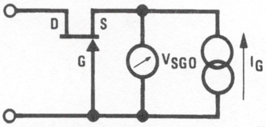
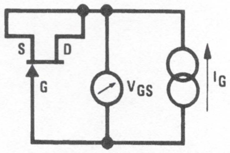
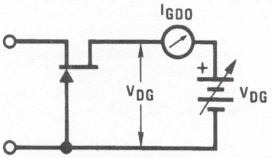
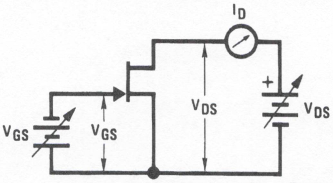
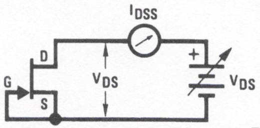
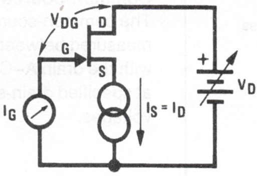
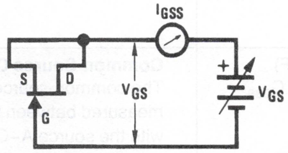
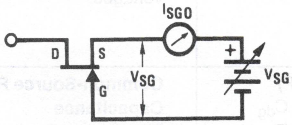
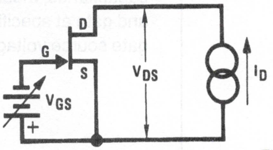
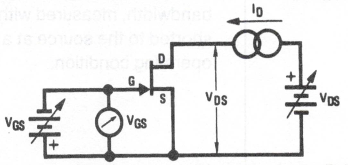
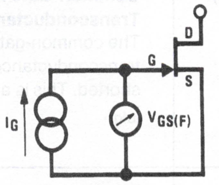
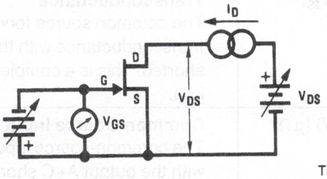
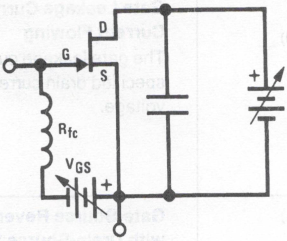
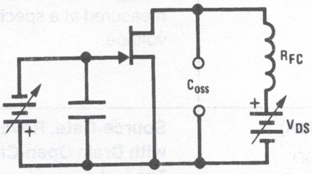
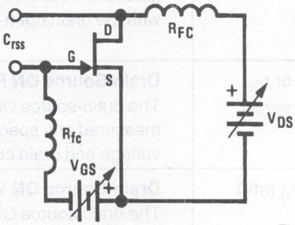
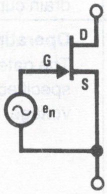
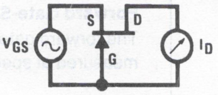
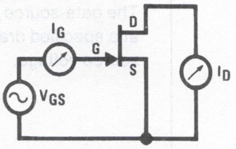
JFET Glossary of Symbols

DC Parameters		
BV_{DGO}(V) or BV_{GDO}	**Drain-Gate Breakdown Voltage with Source Open Circuited** The breakdown voltage of the drain-gate junction, measured at a specified current with the source open-circuit.	 TL/XX/0126-1
BV_{SGO}(V) or BV_{GSO}	**Source-Gate Breakdown Voltage with Drain Open-Circuited** The breakdown voltage of the source-gate junction, measured at a specified current, with the drain open-circuited.	 TL/XX/0126-2
BV_{GSS}(V) or BV, $V_{(BR)GSS}$	**Source-Gate Breakdown Voltage with Drain-Source Shorted** The breakdown voltage of the source-gate and drain-gate junctions, measured at a specified current with the drain-source shorted.	 TL/XX/0126-3
I_{DGO}(pA) or I_{GDO}	**Drain-Gate Leakage Current, Source Open-Circuited** The leakage current of the drain-gate junction, measured at a specified voltage, with the source open-circuited.	 TL/XX/0126-4
I_D(μA) or $I_{D(ON)}$	**Drain ON Current** The drain current, measured at a specified drain-source voltage and gate-source voltage.	 TL/XX/0126-5
$I_{D(OFF)}$(pA)	**Drain Cutoff Current** The drain cutoff current, measured at a specified drain-source voltage and gate-source voltage.	
I_{DSS} (mA)	**Drain Saturation Current** The drain current, measured at a specified drain-source voltage with the source shorted to the gate ($V_{GS} = 0$)	 TL/XX/0126-6

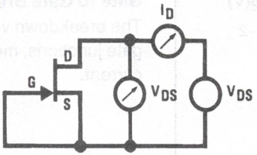
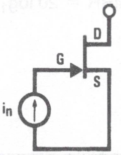
DC Parameters (Continued)

I_G(pA) or $I_{G(ON)}$	**Gate Leakage Current with Drain Current Flowing** The gate leakage current, measured at a specified drain current and drain-gate voltage.	 V_{DG} D G S I_G $I_S = I_D$ + V_{DG} TL/XX/0126-7
I_{GSS}(pA)	**Gate-Source Reverse Leakage Current with Drain-Source Shorted** The gate-source reverse leakage current measured at a specified gate-source voltage.	 TL/XX/0126-8
I_{SGO}(pA) or I_{GSO}	**Source-Gate, Reverse Leakage Current with Drain Open-Circuited** The leakage current of the source-gate junction, measured at a specified voltage, with the drain open-circuited.	 TL/XX/0126-9
DS(Ω) or r_{ds}, R_{DS}, $r_{DS(ON)}$	**Drain-Source ON Resistance** The drain-source ON resistance, measured at a specified gate-source voltage and drain current.	 TL/XX/0126-10
$V_{DS(ON)}$ (mV)	**Drain-Source ON Voltage** The drain-source ON voltage, measured at a specified gate-source voltage and drain current.	
V_{GS}(V) or $V_{GS(ON)}$, V_G	**Operating Gate-Source Voltage** The gate-source voltage, measured at a specified drain current and drain-source voltage.	 I_D D G S V_{DS} + V_{DS} V_{GS} + V_{GS} TL/XX/0126-11
$V_{GS(F)}$(V)	**Forward Gate-Source Voltage** The forward gate-source voltage, measured at specified current.	 TL/XX/0126-12
$V_{GS(OFF)}$(V) or V_P	**Gate-Source Cutoff (Pinch-Off) Voltage** The gate-source cutoff voltage, measured at a specified drain current and drain-source voltage.	 I_D D G S V_{DS} + V_{DS} V_{GS} + V_{GS} TL/XX/0126-13

Small Signal Parameters

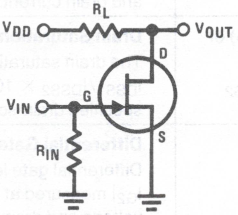
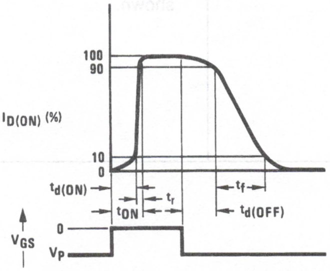
C_{iss}(pF) or C_{is}, C_{gss}	**Common-Source Input Capacitance** The common-source input capacitance measured between the gate and source with the drain A−C shorted to the source at specified drain-source and gate-source voltages.	 TL/XX/0126–14
C_{oss}(pF) or C_{os}, C_{dss}	**Common-Source Output Capacitance** The common-source output capacitance, measured between the drain and source with the source A−C shorted to the gate at specified drain-source and gate-source voltages.	 TL/XX/0126–15
C_{rss}(pF) or C_{rs}, C_{dg}	**Common-Source Reverse Transfer Capacitance** The common-source reverse transfer capacitance, measured between the drain and gate at specified drain-source and gate source voltages.	 C_{rss} D R_{FC} G S + V_{DS} R_{fc} V_{GS} + TL/XX/0126–16
e_n (nV/$\sqrt{\text{Hz}}$ or e_n, V_n, E_n	**Equivalent Input Noise Voltage** The equivalent input noise voltage per unit bandwidth, measured with the input A−C shorted to the source at a specified operating condition.	 TL/XX/0126–17
g_{fg}(mV) (mΩ) or y_{fg}	**Common-Gate Forward Transconductance** The common-gate forward transconductance with the output A−C shorted. This is a complex quantity (g_{fg} + jb_{fg}).	 TL/XX/0126–18 $Y_{fg} = \left.\frac{I_D}{V_{GS}}\right\|_{V_{DS}=0}$
g_{fs}(mV)(mΩ) or g_m, Y_{fs}, Re|Y_{fs}|	**Common-Source Forward Transconductance** The common source forward transconductance with the output A−C shorted. This is a complex quantity (g_{fs} + jb_{fs}).	$Y_{fs} = \left.\frac{I_D}{V_{GS}}\right\|_{V_{DS}=0}$  TL/XX/0126–19
g_{iss} (μV) (μΩ) or Y_{is}	**Common-Source Input Conductance** The common-source input conductance with the output A−C shorted. This is a complex quantity (g_{is} + jb_{is}).	$Y_{is} = \left.\frac{I_G}{V_{GS}}\right\|_{V_{DS}=0}$

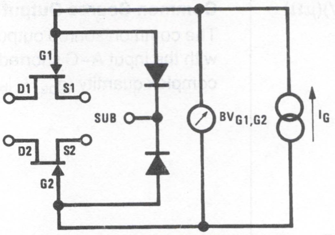
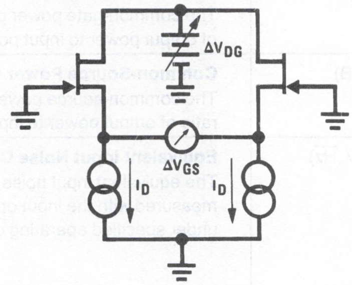
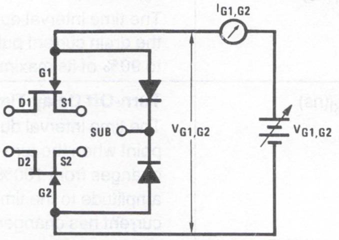
Small Signal Parameters (Continued)

g_{oss} (μV)($\mu\Omega$) or Y_{os}	**Common-Source Output Conductance** The common source output conductance with the input A–C shorted. This is a complex quantity (g_{os} + j_{bos}).	 TL/XX/0126-20 $Y_{os} = \left.\frac{I_D}{V_{DS}}\right\vert V_{GS} = 0$
G_{pg}(dB)	**Common-Gate Power Gain** The common-gate power gain is the ratio of output power to input power.	$G_p = 10\log_{10}\left\vert\frac{P_O}{P_I}\right\vert$
G_{ps}(dB)	**Common-Source Power Gain** The common-source power gain is the ratio of output power to input power.	
i_n (pA/$\sqrt{Hz}$)	**Equivalent Input Noise Current** The equivalent input noise current measured with the input open-circuited under specified operating conditions.	 TL/XX/0126-21
NF (dB)	**Spot Noise Figure** Noise figure = 10 $\log_{10}$ F were F is noise factor which is the ratio of the total output noise power to the output noise power of the source. Measured at specified operating conditions and source resistance.	$F = \frac{\text{Total Output Noise Power}}{\text{Source Output Noise Power}}$

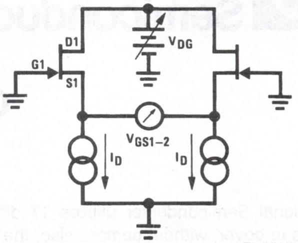
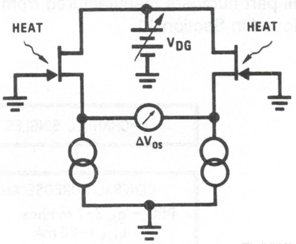
Common-Source Switching Parameters

In the following, drive circuit conditions and drain circuit conditions must be specified. The transition times of the input must be neglible compared to the measured times.

t_d(ns)	**Turn-On Delay Time** The time interval during turn-on from the point when the input pulse at the gate reaches 10% of its full amplitude to the point when the drain pulse changes from 0% to 10% of its maximum amplitude.	 V_{DD} R_L V_{OUT} D V_{IN} G R_{IN} S TL/XX/0126-22
t_r(ns)	**Rise Time** The time interval during turn-on in which the drain current pulse changes from 10% to 90% of its maximum amplitude.	$I_{D(ON)} = \frac{V_{DD} - V_{DS(ON)}}{R_L}$
t_d(ns)	**Turn-Off Delay Time** The time interval during turn-off from the point when the turn-off pulse at the gate changes from 100% to 90% of its full amplitude to the time when the drain current has changed from 100% to 90% of its maximum amplitude.	 TL/XX/0126-23
t_f(ns)	**Fall Time** The time interval during turn-off in which the drain current pulse decreases from 90% to 10% of its maximum amplitude.	

Dual FET Parameters		
$BV_{G1, G2}(V)$ or BV_{G1-2}	**Gate to Gate Breakdown Voltage** The breakdown voltage of the gate to gate junctions, measured at a specified current.	 G1 D1 S1 SUB $BV_{G1,G2}$ I_G D2 S2 G2 TL/XX/0126-24
CMRR (dB) or CMR	**Common-Mode Rejection Ratio** The common-mode rejection ratio is the ratio of the change in differential gate voltage with a change in the drain to gate voltage. $CMRR = 20 \log_{10} \frac{\Delta V_{DG}}{\Delta V_{os}}$	 TL/XX/0126-25
$g_{fs1-2}(\%)$ or g_{fs1}/g_{fs2}	**Common-Source Forward Transconductance Ratio (Match)** The transconductance ratio = g_{fs1}/g_{fs2} × 100% measured at specified drain-gate voltage and drain current.	
$g_{oss1-2}(\mu V)$ or g_{os1-2}	**Common-Source Output Conductance (Match)** Output conductance match = $\lvert g_{os1} - g_{os2} \rvert$ measured at specified drain-gate voltage and drain current.	
$I_{DSS1-2}(\%)$ or I_{DS1-2}, I_{DSS1}/I_{DSS2}	**Drain Saturation Current Ratio (Match)** The drain saturation current ratio = I_{DSS1}/I_{DSS2} × 100% measured at specified drain-source voltages.	
I_{G1-2} (pA)	**Differential Gate Leakage Current** Differential gate leakage current = $\lvert I_{G1} - I_{G2} \rvert$ measured at specified drain-gate voltage and drain current.	
$I_{G1, G2}$(pA)	**Gate to Gate Reverse Leakage Current** The gate to gate reverse leakage measured at a specified voltage monolithic dual with diode isolation shown.	 $I_{G1,G2}$ G1 D1 S1 SUB $V_{G1,G2}$ $V_{G1,G2}$ D2 S2 G2 TL/XX/0126-26

Dual FET Parameters (Continued)

V_{GS1-2} (mV) or ΔV_{GS}, V_{OS}, $\vert V_{GS1}-V_{GS2}\vert$	**Differential Gate-Source Voltage** The differential gate-source voltage, measured at a specified drain-gate voltage and drain current.	 D1 G1 S1 V_{DG} V_{GS1−2} I_D I_D TL/XX/0126-27
ΔV_{GS1-2}(μV/°C) or $\Delta\vert V_{GS1}-V_{GS2}\vert/\Delta T$ $\Delta V_{OS}/\Delta T$	**Differential Gate-Source Voltage Drift** The differential gate-sorce voltage drift is the change in the differential gate-source voltage with a change in device temperature at a specified operating condition. $\frac{\Delta V_{OS}}{\Delta T} = \left\vert \frac{(V_{GS1}-V_{GS2})\vert T_1 - (V_{GS1}-V_{GS2})\vert T_2}{T_1-T_2} \right\vert$	 TL/XX/0126-28

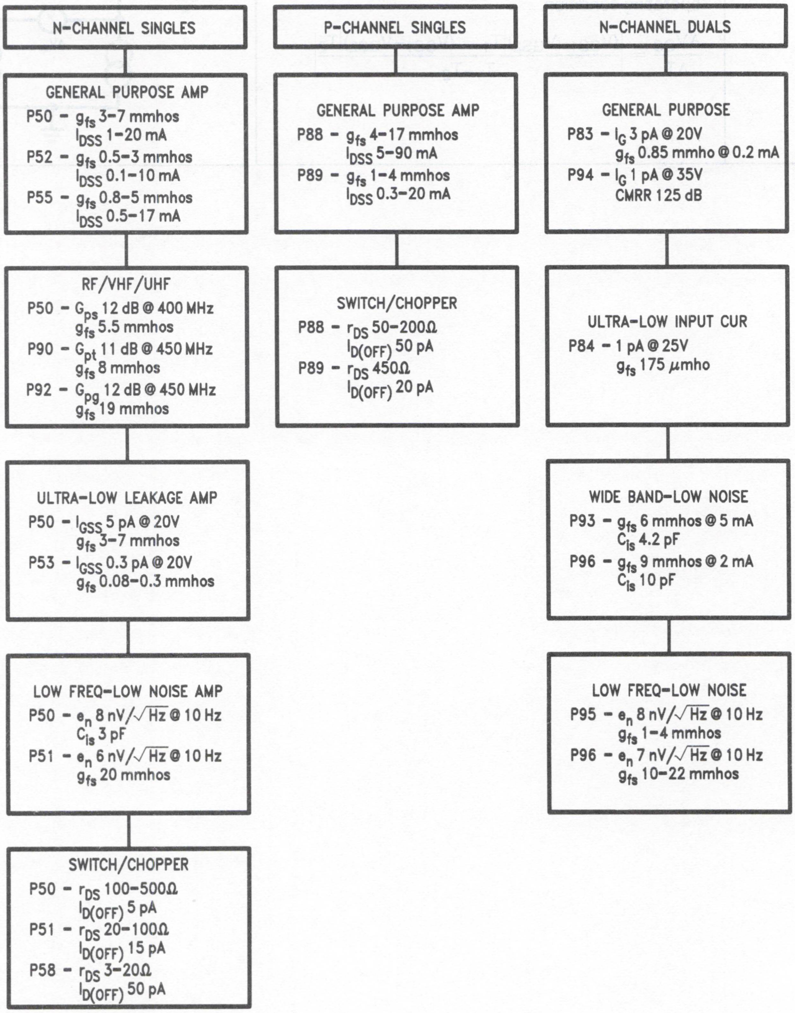
National
Semiconductor

Choose the Proper FET

National Semiconductor utilizes 17 different FET geometries to cover, without compromise, the full spectrum of applications. Detailed data on each process, along with a list of all part numbers manufactured from each process, is to be found in Section 11.

To further simplify the selection procedure, the FET Family Tree is included for quick identification. After narrowing down the process types, it is suggested that the process sheets and specific part number characteristics be consulted.

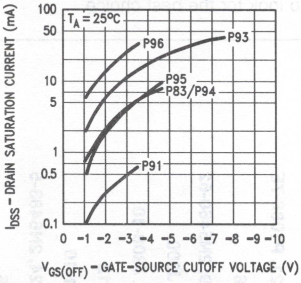
FET FAMILY TREE


N-CHANNEL SINGLES
GENERAL PURPOSE AMP
P50 – g_{fs} 3–7 mmhos
I_{DSS} 1–20 mA
P52 – g_{fs} 0.5–3 mmhos
I_{DSS} 0.1–10 mA
P55 – g_{fs} 0.8–5 mmhos
I_{DSS} 0.5–17 mA
RF/VHF/UHF
P50 – G_{ps} 12 dB @ 400 MHz
g_{fs} 5.5 mmhos
P90 – G_{pt} 11 dB @ 450 MHz
g_{fs} 8 mmhos
P92 – G_{pg} 12 dB @ 450 MHz
g_{fs} 19 mmhos
ULTRA-LOW LEAKAGE AMP
P50 – I_{GSS} 5 pA @ 20V
g_{fs} 3–7 mmhos
P53 – I_{GSS} 0.3 pA @ 20V
g_{fs} 0.08–0.3 mmhos
LOW FREQ–LOW NOISE AMP
P50 – e_n 8 nV/$\sqrt{Hz}$ @ 10 Hz
C_{is} 3 pF
P51 – e_n 6 nV/$\sqrt{Hz}$ @ 10 Hz
g_{fs} 20 mmhos
SWITCH/CHOPPER
P50 – r_{DS} 100–500Ω
$I_{D(OFF)}$ 5 pA
P51 – r_{DS} 20–100Ω
$I_{D(OFF)}$ 15 pA
P58 – r_{DS} 3–20Ω
$I_{D(OFF)}$ 50 pA
P-CHANNEL SINGLES
GENERAL PURPOSE AMP
P88 – g_{fs} 4–17 mmhos
I_{DSS} 5–90 mA
P89 – g_{fs} 1–4 mmhos
I_{DSS} 0.3–20 mA
SWITCH/CHOPPER
P88 – r_{DS} 50–200Ω
$I_{D(OFF)}$ 50 pA
P89 – r_{DS} 450Ω
$I_{D(OFF)}$ 20 pA
N-CHANNEL DUALS
GENERAL PURPOSE
P83 – I_G 3 pA @ 20V
g_{fs} 0.85 mmho @ 0.2 mA
P94 – I_G 1 pA @ 35V
CMRR 125 dB
ULTRA-LOW INPUT CUR
P84 – 1 pA @ 25V
g_{fs} 175 μmho
WIDE BAND–LOW NOISE
P93 – g_{fs} 6 mmhos @ 5 mA
C_{is} 4.2 pF
P96 – g_{fs} 9 mmhos @ 2 mA
C_{is} 10 pF
LOW FREQ–LOW NOISE
P95 – e_n 8 nV/$\sqrt{Hz}$ @ 10 Hz
g_{fs} 1–4 mmhos
P96 – e_n 7 nV/$\sqrt{Hz}$ @ 10 Hz
g_{fs} 10–22 mmhos

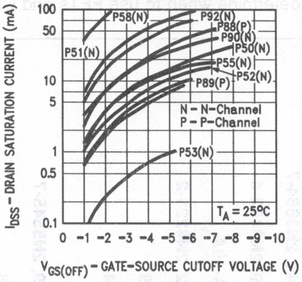
TL/XX/0123–1

Typical Performance Characteristics

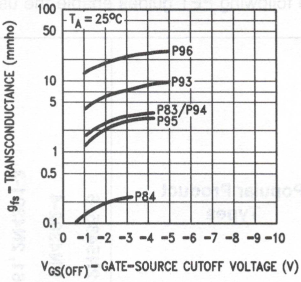
Dual FET Drain Saturation Current vs Cutoff Voltage



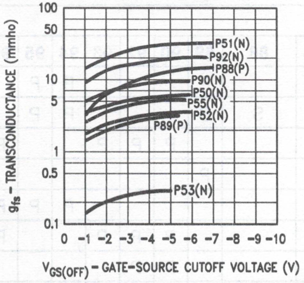
Single FET Drain Satturation Current vs Cutoff Voltage



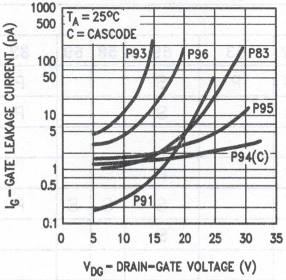
Dual FET Transconductace vs Cutoff Voltage



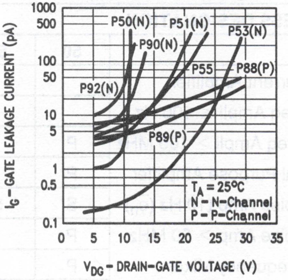
Single FET Transconductance vs Cutoff Voltage



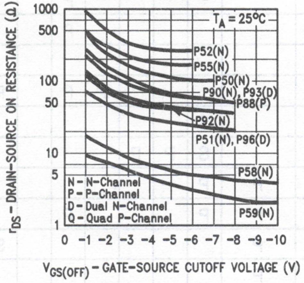
Dual FET Gate Leakage Current vs Drain-Gate Voltage



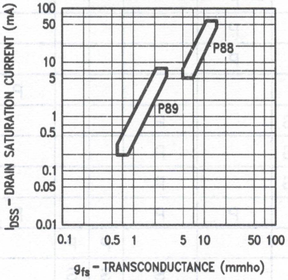
Single FET Gate Leakage Current vs Drain-Gate Voltage



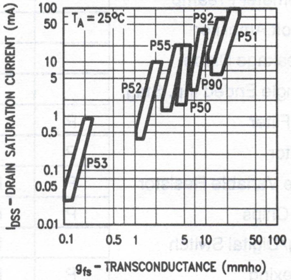
ON Resistance vs Cutoff Voltage



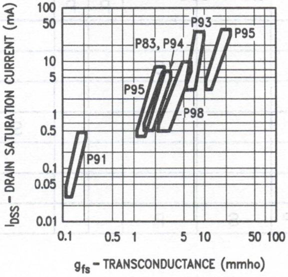
Single P-Channel FET Process Distribution I_{DSS} vs g_{fs}



Single N-Channel FET Process Distribution I_{DSS} vs g_{fs}



Monolithic Dual FET Process Distribution I_{DSS} vs g_{fs}



TL/XX/0123-2

FET Application Guide

National Semiconductor manufactures a broad line of silicon Junction Field Effect Transistors (JFETs). National's JFETs provide excellent performance in many areas such as RF amplifiers, analog switching, low input current amplifiers, low noise high impedance amplifiers and outstanding matched duals for operational amplifiers input applications.

The following FET guides enable the user to determine when to use FETs and where to look for the best choice.

Popular Product Types	2N4416, 2N5485, 6 PN4416, PN4302-4	2N4856-61, 2N4391-3 PN4856-61, PN4391-3	2N4338-41, 2N3684-7	2N4117-9, 2N3452-4 2N4117A-19A	2N3821-2, 2N4221-2 2N5457-9	2N5432-4	J106-7	2N5196-9, 2N5545-7 2N3954-8	2N5902-9	2N5018-21, P1086-7E 2N5114-6	2N2608-9, 2N5460-62	2N5397, J300	U308-10, J308-10	2N5911-12	NDF9401-10	2N5515-24, 2N6483-5	2N5564-6	2N5561-63
PROCESS DESIGNATION	50	51	52	53	55	58	59	83	84	88	89	90	92	93	94	95	96	98
Low Current Amplifier			S	P	S			P	P		P				P	P		P
Low Freq Ampli ≤ 100 Hz			S		S			P		S	S				P	P		P
High Freq Ampli > 100 MHz	P											P	P	P			P	
General Purpose Amplifier	P		P		P						P							
Low Noise Amp (10 Hz ($\bar{e}_n$)	S	S			S	S	S	P							P	P	P	P
Low Noise Amp > 50 MHz	P				S							P	P	P			P	
High Frequency Mixer	P											P	P					
Dual Diff Pair								P	P					P	P	S	P	P
AGC Amplifier	P				P													
Electrometer Preamp				P					P						P			S
Microvolt Amplifier				P					P						P			P
Low Leakage Diode				P														
Diff/Angle Ended Inp. Stag.								P	P					P	P		P	P
Active Filter	P		S		P						S							
Oscillator	P		S		P						S	P	P					
Voltage Variable Resistor	P	P	S		P					P	P							P
Hybrid Chips	P	P		P	P			P	P	P	P				P			
Analog/Digital Switch		P				P	P			P							S	S
Multiplexing	P	P			S	S	S			P								
Choppers		P				P	P			P							P	
Nixie Drivers																		
Reed Relay Replacement						P	P											
Sub pA Dual Diff Pair									P									
Sample-Hold	P	P			S					P								P
Buffer Interface to CMOS										P	P							
Matched Switch								S						S	S		P	P
HF > 400 MHz Prime												P	P					
Current Limiter		P								P								
Current Source			P	S	P						S							

P— Prime Choice

S— Secondary (Alternate) Choice

FET Application Guide (Continued)

Advantages of Using Field-Effect Transistors (Continued)

Application	Advantages	Final Assembly Where Used
DC Amplifiers	High Z_{in} Low Drift Duals Low Noise	Transducers, Military Guidance Systems, Control Systems, Temp Indicators, Multimeters
Low Frequency Amplifiers	Small Coupling Capacitors Low Noise, Distortion High Input Impedance	Sound Detection, Microphones, Inductive Transducers, Hearing Aids, High Impedance Transducers
Operational Amplifiers	Summing Point Essentially Zero. Low Device Noise. Less Loading of Transducers	Control Systems, Potted Op Amps, Test Equipment, Medical Electronics
Medium and High Frequency Amplifiers	Low Cross Modulation Low Device Noise	FM Tuners, Communication Received Scope Inputs, Most Instrumentation Equipment, High Impedance Inputs
Mixer—100 MHz and Up	Low Mixing Noise Low Cross Modulation	FM Tuners, Communication Receivers
Oscillators	Low Drift	Transmitters, Receivers, Organ
Logic Gates	Virtually Infinite Fan in Simplified Circuitry Zero Storage Time Symmetrical	Guidance Controls, Computer Market Mini Military Teaching Aids, Traffic Control, Telemetry
Choppers	Zero Offset Low Leakage Currents Simplified Circuitry Eliminates Input Transformers	Op Amp Modules Guidance Controls Instrumentation Equipment
AD Converters Multiplex Switching (Arrays) and Sample Hold	Improved Isolation of Input and Output. Zero Offset. Symmetrical. Low Resistance Simplified Circuitry	Control System, DVM's and Any Readout Equipment, Medical Electronics
Relay Contact Replacement	Solid State Reliability Zero Offset, High Isolation Symmetrical No Inductive Spring No Contact Bounce High Repetition Rate	Test Equipment, Airborne Equipment Instrumentation Market
Voltage Variable Resistor	Symmetrical Solid State Reliability Functions as Variable Resistor. Low Noise. High Isolation Improved Resolution	Organ, Tone Controls, Control Circuits to Input Operational Amplifiers
Current Limiters Sources	Two Lead Simplicity Wide Selection Range Low Voltage Operation	Hybrid Circuits, Amplifiers, Power Supply Protection, Timing Circuits, Voltage Regulators

Important Parameters by Application

Listed in Approxmiate Order of Importance

Low Frequency Amplifier	Source Follower	Electrometer Amplifier	Low Drift Amplifier	Low Noise Amplifier	High Frequency Amplifier	Oscillator	Differential Amplifier	Analog and Digital Switch
Yfs	Yfs	I_G	I_{DZ}	e_n	Re(yfs)	yfs	$\|V_{GS1} - V_{GS2}\|$	$R_{DS(on)}$
I_{DSS}	I_G	yfs	yfs @ I_{DZ}	I_G	Re(yfs)	I_{DSS}	$\frac{\Delta\|V_{GS1} - V_{GS2}\|}{\Delta T}$	$I_{D(off)}$
$V_{GS(off)}$	C_{rss}	I_{DZ}	V_{GS} @ I_{DZ}	i_n	NF	C_{rss}	$\|I_{G1} - I_{G2}\|$	C_{iss}
C_{iss}	C_{iss}	e_n	I_G	yfs	C_{rss}	C_{iss}	I_G	C_{rss}
C_{rss}	I_{DSS}	g_{os}	BV_{GSS}	I_{DSS}	Re(y_{os})	$V_{GS(off)}$	yfs	$V_{GS(off)}$
e_n	$V_{GS(off)}$			$V_{GS(off)}$	I_{DSS}	BV_{GSS}	yfs1/yfs2	BV_{GSS}
BV_{GSS}	BV_{GSS}				$V_{GS(off)}$		$\|y_{os1} - y_{os2}\|$	
							CMRR	
							$V_{GS(off)}$	

Introduction to Power Supplies

National Semiconductor
Application Note 557
Ralph E. Locher

INTRODUCTION

Virtually every piece of electronic equipment, e.g., computers and their peripherals, calculators, TV and hi-fi equipment, and instruments, is powered from a DC power source, be it a battery or a DC power supply. Most of this equipment requires not only DC voltage but voltage that is also well filtered and regulated. Since power supplies are so widely used in electronic equipment, these devices now comprise a worldwide segment of the electronics market in excess of $5 billion annually.

There are three types of electronic power conversion devices in use today which are classified as follows according to their input and output voltages: 1) the AC/DC power supply; 2) DC/DC converter; 3) the DC/AC inverter. Each has its own area of use but this paper will only deal with the first two, which are the most commonly used.

A power supply converting AC line voltage to DC power must perform the following functions at high efficiency and at low cost:

1. Rectification: Convert the incoming AC line voltage to DC voltage.
2. Voltage transformation: Supply the correct DC voltage level(s).
3. Filtering: Smooth the ripple of the rectified voltage.
4. Regulation: Control the output voltage level to a constant value irrespective of line, load and temperature changes.
5. Isolation: Separate electrically the output from the input voltage source.
6. Protection: Prevent damaging voltage surges from reaching the output; provide back-up power or shut down during a brown-out.

An ideal power supply would be characterized by supplying a smooth and constant output voltage regardless of variations in line voltage, load current or ambient temperature at 100% conversion efficiency. *Figure 1* compares a real power supply to this ideal one and further illustrates some power supply terms.

LINEAR POWER SUPPLIES

Figure 2 illustrates two common linear power supply circuits in current use. Both circuits employ full-wave rectification to reduce ripple voltage to capacitor C1. The bridge rectifier circuit has a simple transformer but current must flow through two diodes. The center-tapped configuration is preferred for low output voltages since there is just one doide voltage drop. For 5V and 12V outputs, Schottky barrier diodes are commonly used since they have lower voltage drops than equivalently rated ultra-fast types, which further increases power conversion efficiency. However, each diode must withstand twice the reverse voltage that a diode sees in a full-wave bridge for the same input voltage.

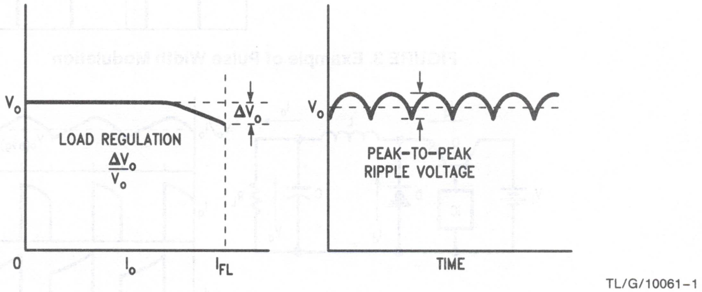
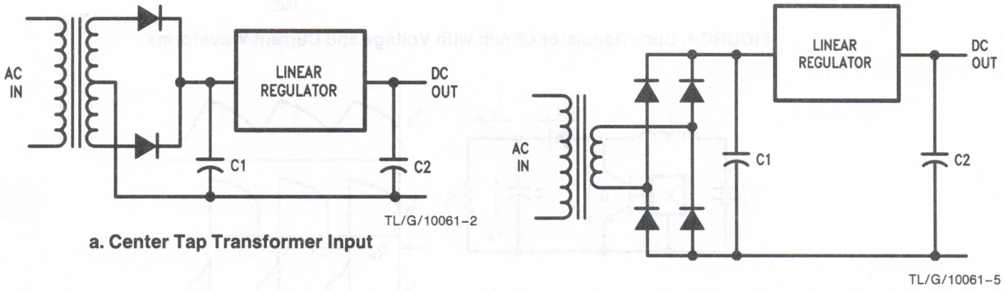


FIGURE. 1. Idealized Power Supply



a. Center Tap Transformer Input

b. Full-Wave Bridge Input

FIGURE 2. Linear Voltage Regulator

The linear voltage regulator behaves as a variable resistance between the input and the output as it provides the precise output voltage. One of the limitations to the efficiency of this circuit is due to the fact that the linear device must drop the difference in voltage between the input and output. Consequently the power dissipated by the linear device is $(V_i - V_o) \times I_o$. While these supplies have many desirable characteristics, such as simplicity, low output ripple, excellent line and load regulation, fast response time to load or line changes and low EMI, they suffer from low efficiency and occupy large volumes. Switching power supplies are becoming popular because they offer better solutions to these problems.

SWITCHING POWER SUPPLIES

Pulse Width Modulation

In the early 60's, switching regulators started to be designed for the military, who would pay a premium for light weight and efficiency. One way to control average power to a load is to control average voltage applied to it. This can be done by opening and closing a switch in rapid fashion as being done in *Figure 3*.

The average voltage seen by the load resistor R is equal to:

$$V_{o(avg)} = (t_{(on)}/T) \times V_i \quad \text{(A)}$$

Reducing $t_{(on)}$ reduces $V_{o(avg)}$. This method of control is referred to as pulse width modulation (PWM).

Buck Regulator

As we shall see, there are many different switching voltage regulator designs. The first one to be considered because of its simplicity is the buck regulator *(Figure 4)*, also known as a step-down regulator since the output voltage as given by equation (A) is less than the input voltage. A typical application is to reduce the standard military bus voltage of 28V to 5V to power TTL logic.

At time $t_{(0)}$ in *Figure 4,* the controller, having sensed that the output voltage V_o is too low, turns on the pass transistor to build up current in L, which also starts to recharge capacitor C. At a predetermined level of V_o, the controller switches off the pass transistor Q, which forces the current to free wheel around the path consisting of L, C, and the ultra-fast rectifier D. This effectively transfers the energy stored in the inductor L to the capacitor. Inductor and capacitor sizes are inversely proportional to switching frequency, which accounts for the increasing power density of switching power supplies. Power MOSFETs are rapidly replacing bi-polar transistors as the pass transistor because of their high frequency capability. Since the pass transistor must not only carry load current but reverse recovery current of diode D, an ultra-fast recovery diode is mandatory.

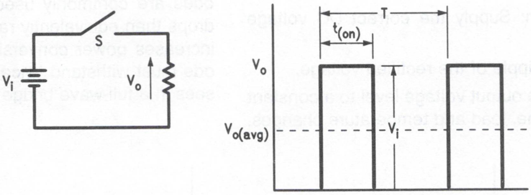


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FIGURE 3. Example of Pulse Width Modulation

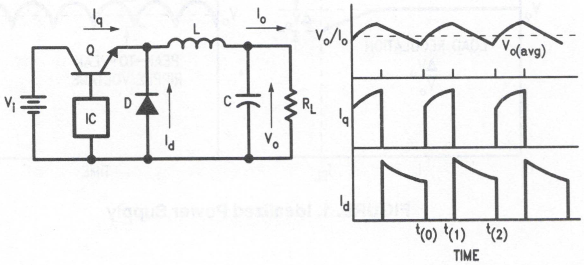

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FIGURE 4. Buck Regulator Circuit with Voltage and Current Waveforms

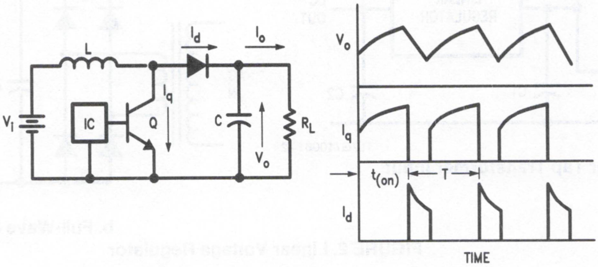

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FIGURE 5. Boost Regulator and Associated I/V Waveforms

Boost Regulator

A second type of regulator shown in *Figure 5* is capable of boosting the input voltage. Applications for this circuit would be to increase 5V battery sources to 15V for CMOS circuits or even to 150V for electro-luminescent displays.

The concept of this circuit is still the same as the previous, namely to transfer the energy stored in the inductor into the capacitor. The inductor current can ramp up quickly when the transistor switch is closed at time $t_{(0)}$ since the full input voltage is applied to it. The transistor is turned off at time $t_{(1)}$ which forces the inductor current to charge up the capacitor through the ultra-fast diode D. Since the energy stored in the inductor is equal to L x I x ½, the PWM IC can increase V_O by increasing its own on-time to increase the peak inductor current before switching. The transfer function is:

$$V_O = V_{IN}\,(T/(T - t_{(on)})) \qquad \text{(B)}$$

Inverting Regulator

Figure 6 shows a switching circuit which produces an output voltage with the opposite polarity of the input voltage. This circuit works in the same fashion as the boost converter but has achieved the voltage inversion by exchanging positions of the transistor and inductor. The circuit is also known as a buck-boost regulator since the absolute magnitude of the output voltage can be higher or lower than the input voltage, depending upon the ratio of on-time to off-time of the pass transistor.

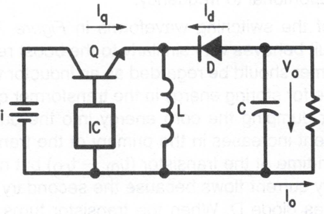

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FIGURE 6. Inverting Regulator and I/V Waveforms

Flyback Converter

The three previous regulators are suitable for low voltage control when no electrical isolation is required. However in off-line switchers operating from 110V/220V mains, electrical isolation is an absolute must. This is achieved by using a transformer in place of the inductor. The flyback converter shown in *Figure 7* is commonly used in power supplies up through 150W, which is sufficient for most personal computers, many test instruments, video terminals and the like.

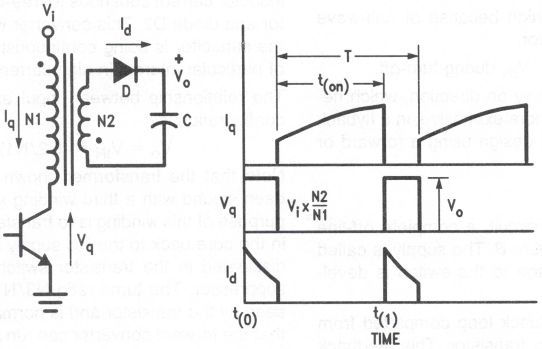

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FIGURE 7. Flyback Converter

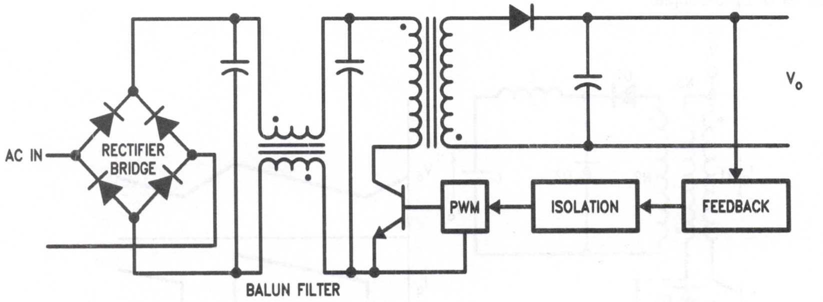

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FIGURE 8. Complete Flyback Switching Supply

Since the transformer operates at high frequency, its size is much smaller than a 50 Hz/60 Hz transformer shown in *Figure 2*. Within certain frequency limits, transformer size is inversely proportional to frequency.

Inspection of the switching waveforms in *Figure 7* shows that the circuit behaves very similarly to the boost regulator. The transformer should be regarded as an inductor with two windings, one for storing energy in the transformer core and the other for dumping the core energy into the output capacitor. Current increases in the primary of the transformer during the on-time of the transistor ($t_{(0)} - t_{(1)}$) but note that no secondary current flows because the secondary voltage reverse biases diode D. When the transistor turns off, the transformer voltage polarities reverse because its magnetic field wants to maintain current flow. Secondary current can now flow through the diode to charge up the output capacitor. The output voltage is given by the basic PWM equation times the transformer turns ration (N2/N1):

$$V_o = V_{IN} \times (t_{(on)}/(T - t_{(on)}) \times (N2/N1) \qquad (C)$$

Voltage control is achieved by controlling the transistor on-time to control the peak primary current.

The flyback converter is well suited for multiple output and high voltage power supplies since the transformer inductance replaces the filter inductor(s). The major disadvantages which limit its use to lower wattage supplies are:

1. The output ripple voltage is high because of half-wave charging of the output capacitor.
2. The transistor must block 2 × V_{IN} during turn-off.
3. The transformer is driven in only on direction, which necessitates a larger core, i.e., more expensive, in a flyback design than for an equivalent design using a forward or push-pull design.

Off-Line Switching Supply

Based on the flyback regulator circuit, a complete off-line switching supply is shown in *Figure 8*. The supply is called "off-line" because the DC voltage to the switch is developed right from the AC line.

The circuit also shows the feedback loop completed from the output back to the switching transistor. This feedback loop must have isolation in order for the DC output to be isolated from the AC line. This is normally accomplished by a small transformer or opto-coupler.

Switching power supplies designed for international usage must have selectable AC input voltage ranges of 115V and 230V. *Figure 9* shows how this is accomplished for many switching power supplies.

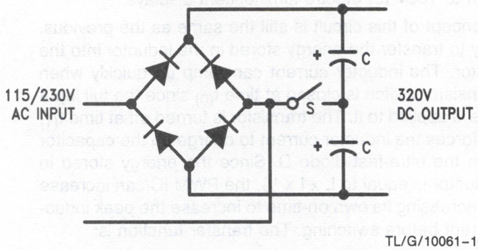

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FIGURE 9. Selector Switch for 115V/230V inputs

Forward Converter

Although the forward converter is not as well-known as the flyback converter, it is becoming increasingly popular for power supplies in the 100W–500W range. *Figure 10* shows the basic circuit of the forward converter. When the transistor is switched on, current rises linearly in the primary and secondary current also flows through diode D1 into the inductor and capacitor. When the transistor switch is opened, inductor current continues to free-wheel through the capacitor and diode D2. This converter will have less ripple since the capacitor is being continuously charged, an advantage of particular interest in high current supplies.

The relationship between input and output for this circuit configuration is:

$$V_o = V_{IN} \times (N2/N1) \times (t_{(on)}/T) \qquad (D)$$

Note that the transformer shown in the above figure has been wound with a third winding and series diode D3. The purpose of this winding is to transfer the magnetizing energy in the core back to the DC supply so it does not have to be dissipated in the transistor switch or some other voltage suppressor. The turns ratio N3/N1 limits the peak voltage seen by the transistor and is normally chosen equal to 1 so that the forward converter can run at 50% duty cycle. Under this condition, the transistor must block 2 × V_{IN} during turn-off.

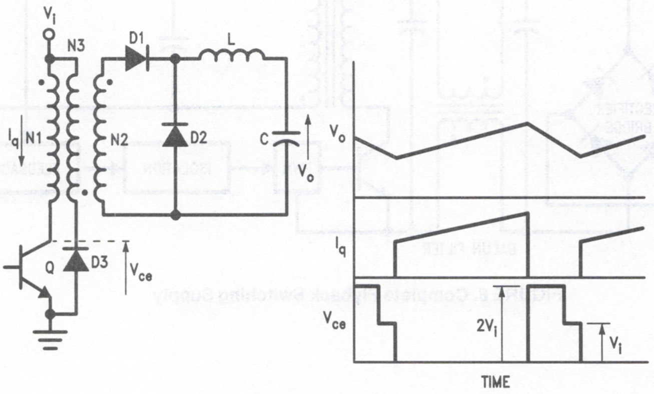

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FIGURE 10. Forward Converter

SYMMETRICAL CONVERTERS

Push-Pull Converter

The circuit for this best-known and widely used converter is shown in *Figure 11*.

Transistors Q1 and Q2 are alternately switched on for time period $t_{(on)}$. This subjects the transformer core to an alternating voltage polarity to maximize its usefulness. The transfer function still follows the basic PWM formula but there is the added factor 2 because both transistors alternately conduct for a portion of the switching cycle.

$$V_o = 2 \times V_{IN} \times (N2/N1) \times (t_{(on)}/T) \qquad (E)$$

The presence of a dead time period $t_{(d)}$ is required to avoid having both transistors conduct at the same time, which would be the same as turning the transistors on into a short circuit. The output ripple frequency is twice the operating frequency which reduces the size of the LC filter components. Note the anti-parallel diodes connected across each transistor switch. They perform the same function as diode D3 in the forward converter, namely to return the magnetization energy to the input voltage whenever a transistor turns off.

Compared to the following symmetrical converters, this circuit has the advantage that the transistor switches share a common signal return line. Its chief disadvantages are that the transformer center-tap connection complicates the transformer design and the primary windings must be tightly coupled in order to avoid voltage spikes when each transistor is turning off.

Half-Bridge Converter

This converter *(Figure 12)* operates in much the same fashion as the previous push-pull circuit.

The input capacitors C1 and C2 split the input voltage equally so that when either transistor turns on, the transformer primary sees $V_{in}/2$. Consequently note no factor of "2" in the following transfer equation:

$$V_o = V_{IN} \times (N2/N1) \times (t_{(on)}/T) \qquad (F)$$

Since the two transistors are connected in series, they never see more than the input voltage V_{IN} plus the inevitable switching transient voltages. The necessity of a dead time is even more obvious here since the simultaneous conduction of both transistors results in a dead short across the input supply. Anti-parallel ultra-fast diodes return the magnetization energy as in the push-pull circuit but alternately to capacitors C1 and C2. This circuit has the slight inconvenience of requiring an isolated base drive to Q1, but since most practical base drive circuits use a transformer for isolation, this shortcoming is hardly worth noting.

Full-Bridge Converter

Because of its complexity and expense, the full-bridge converter circuit of *Figure 13* is reserved for high power converters. Ideally, all voltages are shared equally between two transistors so that the maximum voltage rating of the device can approach V_{IN}.

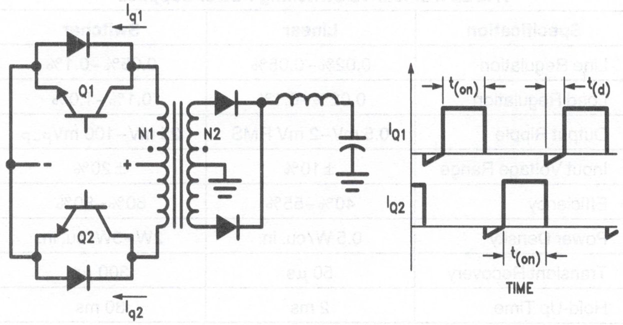

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FIGURE 11. Push-Pull Converter

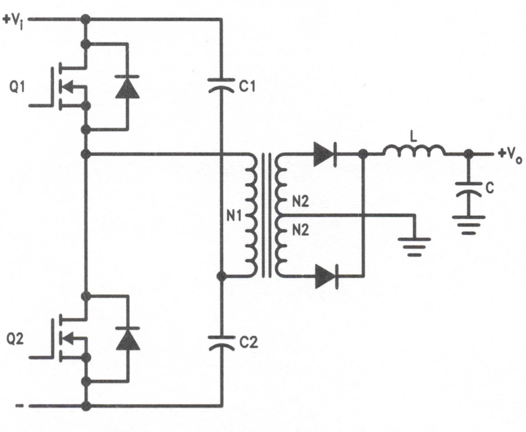

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FIGURE 12. Half-Bridge Converter Circuit

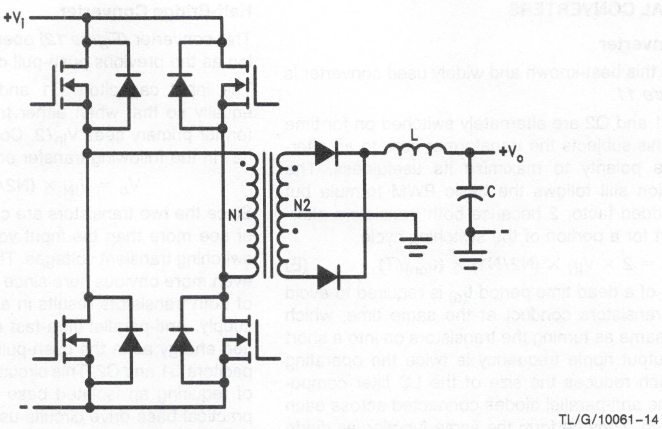

FIGURE 13. Full-Bridge Converter Circuit

Switching vs Linear Power Supplies

Switching power supplies are becoming popular due to high efficiency and high power density. Table I compares some of the salient features of both linear and switching power supplies. Line and load regulation are usually better with linear supplies, sometimes by as much as an order of magnitude, but switching power supplies frequently use linear post-regulators to improve output regulation.

DC-DC CONVERTERS

DC-DC converters are widely used to transform and distribute DC power in systems and instruments. DC power is usually available to a system in the form of a system power supply or battery. This power may be in the form of 5V, 28V, 48V or other DC voltages. All of the previously discussed circuits are applicable to this type of duty. Since voltages are low, isolation is not usually required.

TABLE I. Linear vs Switching Power Supplies

Specification	Linear	Switcher
Line Regulation	0.02%–0.05%	0.05%–0.1%
Load Regulation	0.02%–0.1%	0.1%–1.0%
Output Ripple	0.5 mV–2 mV RMS	25 mV–100 mV$_{P-P}$
Input Voltage Range	±10%	±20%
Efficiency	40%–55%	60%–80%
Power Density	0.5 W/cu. in.	2W–5W/cu. in.
Transient Recovery	50 μs	300 μs
Hold-Up Time	2 ms	30 ms

Optimizing the Ultra-Fast POWERplanar™ Rectifier Diode for Switching Power Supplies

National Semiconductor
Application Note 557
Ralph E. Locher

INTRODUCTION

A key device in all high voltage AC-DC power supplies is the ultrafast, reverse recovery rectifier diode. These diodes (D1 and D2 in *Figure 1*) not only play a major role in power supply efficiency but also can be major contributors to circuit electromagnetic interference (EMI) and even cause transistor failure if they are not selected correctly. One would assume that by now, this rectifier diode should approximate the behavior of an ideal switch, i.e., zero on-state voltage, no reverse leakage current and instantaneous turn-on. At first glance, the design of this single pn-junction device would appear to be quite straight forward but a review of the device equations reveals that many compromises must be made to optimize its performance. An understanding of these tradeoffs will allow the circuit designer to select the most appropriate rectifier diode.

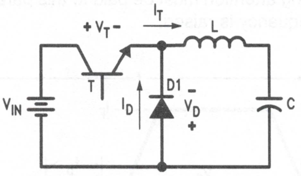

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FIGURE 1a. Buck Regulator to Step-Down Input Voltage V_{IN}

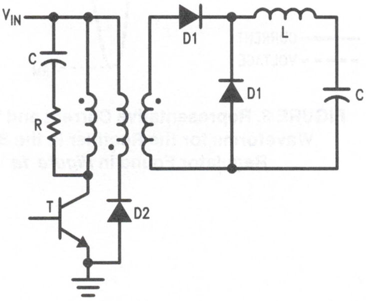

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FIGURE 1b. Forward Converter

Consider how the non-ideal behavior of rectifier D2 affects the circuit performance of the buck regulator in *Figure 1a*. The solid lines in *Figure 2a* depict the switching behavior of the transistor switch and rectifier in comparison to the waveforms (dashed lines) that represent an ideal rectifier. There are four differences between the two cases:

1. The most significant difference is that the peak collector current of the transistor switch (I_T in *Figure 2a*) at the end of turn-on (time t_2) has been increased by the magnitude of the peak reverse recovery current of the rectifier ($I_{R(REC)}$). Correspondingly, the peak power dissipation within the transistor has increased from P_T to P_T as shown in *Figure 2c*.
2. The maximum transistor voltage V_T at turn-off (t_4–t_6 in *Figure 2a*) has been increased by the dynamic voltage drop of the rectifier during turn-on. Since buck regulators generally run at low voltages, this increase has a minimal effect. However, it is more significant in the forward converter circuit of *Figure 1b* and in bridge circuits operating from high bus voltages where the voltage margins cannot be as generous.
3. Since the rectifier is not ideal, its power dissipation consists of the following components:
   a. Conduction loss ($V_F \times I_F$) during the on-time.
   b. Turn-off loss during time t_2–t_3 and turn-on loss during time t_5–t_6 *(Figure 2d)*.
   c. Reverse blocking loss ($V_R \times I_R$) during period t_3–t_5.
4. The rectifier regains its reverse blocking capability at time t_2. A "snappy" rectifier that quickly turns off $I_{R(REC)}$ will contribute much more EMI than a "soft", fast recovery rectifier.

A better transistor switch will intensify rather than improve the shortcomings of the fast recovery rectifier, so it is necessary to consider more fully the conduction and switching behavior of the rectifier diode.

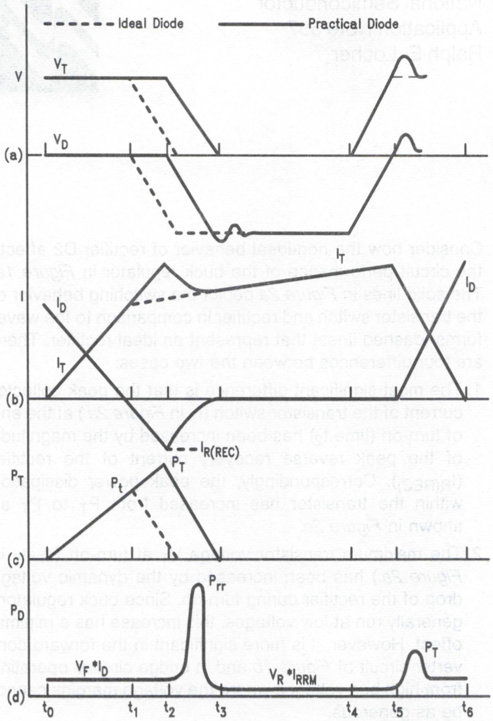

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FIGURE 2. Transistor and Rectifier Voltage and Current Waveforms for the Buck Regulator in *Figure 1a*
a) Transistor and Rectifier Voltage Waveforms
b) Transistor and Rectifier Current Waveforms
c) Transistor Power Dissipation
d) Rectifier Power Dissipation

POWER LOSSES IN THE ULTRA-FAST RECTIFIER DIODE

Consider the idealized rectifier current and voltage waveforms in *Figure 3* for a 50 kHz buck regulator. Power dissipation within the rectifier for a 50% duty factor is:

$$P = P(\text{conduction}) + P(\text{blocking}) + P(\text{reverse recovery})$$

$$P = \frac{1}{2}(V_F I_F + V_R I_R) + V_{RM} I_{R(REC)} t_b f$$

Typical values for a 200V, 8A rectifier are:

$f = 50$ kHz
$V_F = 0.9$V
$I_F = 8$A
$I_{R(REC)} = 2.0$A
$I_R = 1$ mA
$t_B = 25$ ns (assuming $t_b = t_{rr}/2$)
$V_R = 50$V
$V_{RM} = 200$V

$$P = \frac{1}{2}[(8A)\ (0.9V) + (50V)\ (1\ mA)]$$
$$+ (200V)\ (2A)\ (25\ ns)\ (50\ kHz)$$
$$P = 3.6W + 0.025W + 0.5W = 4.125W$$

CONDUCTION LOSSES

DC conduction or on-state losses occur whenever the rectifier is conducting forward current and consists simply of the integration of I_F x V_F during the on-time. Literature has dealt extensively with the computation of V_F for many different rectifier structures (Reference 1). The National Semiconductor POWERplanar™ line of fast recovery diodes are planar passivated, P + N − N+ epitaxial type, for which a cross-sectional view can be found in *Figure 4*. It can be shown that V_F is inversely proportional to minority carrier lifetime and directly proportional to epitaxial thickness (Wi in *Figure 4*).

Figure 5 plots theoretical curves of normalized V_F vs minority carrier lifetimes for rectifiers with 250V and 500V avalanche voltage breakdown. Since t_{rr} is approximately equal to minority carrier lifetime, it is apparent that high current pn-junction rectifiers are limited to 20 ns–50 ns reverse recovery times because V_F dramatically increases for minority carrier lifetimes less than these. It is also apparent that the V_F curves have a broad minima around 10 ns–30 ns so that another reason to select this value of minority carrier lifetime is that V_F becomes independent of small changes in minority carrier lifetime due to manufacturing tolerances.

It is immediately obvious that the key to maximizing current through the rectifier is to minimize V_F. However at 200 kHz, reverse recovery losses will quadruple to 4W, so that increasing attention must be paid to this parameter as operating frequency is raised.

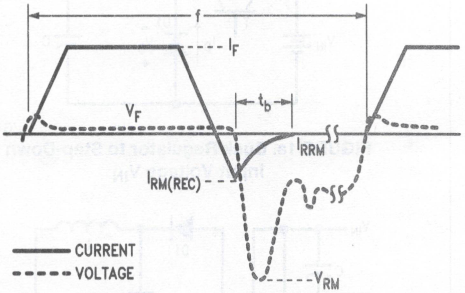

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FIGURE 3. Representative Current and Voltage Waveforms for the Rectifier in the Buck Regulator Found in *Figure 1a*

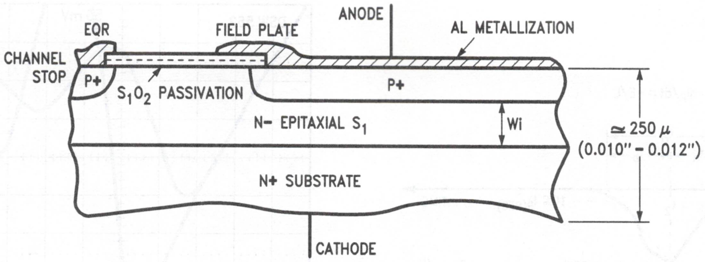

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FIGURE 4. Cross-Sectional View of a POWERplanar™ P + N − N+, Fast Recovery Rectifier

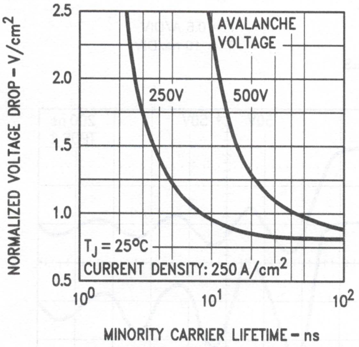

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FIGURE 5. Normalized V_F for 250V and 500V Rated Rectifiers as a Function of Minority Carrier Lifetime

REVERSE BLOCKING LOSSES

Planar passivation techniques have reduced surface leakage currents (I_R) to a negligible amount so that the principle reverse leakage current is recombination current in the space charge region. Some of the many methods to control minority carrier lifetimes are electron or neutron irradiation and gold or platinum diffusion, each with its own advantages and disadvantages. For 200V, ultrafast recovery rectifiers, gold diffusion still represents the best compromise between speed, V_F, I_R and "soft" recovery.

A drawback to gold diffusion is its relatively high reverse leakage current. It should be pointed out that the reliability of the gold-diffused product is the same as other rectifiers (all other factors being equal), since this leakage current is a bulk and not a surface phenomenon. *Figure 6* illustrates the dependency of recombination current on junction temperature and minority carrier lifetime, which is inversely proportional to the amount of gold in the depletion region. Experimental leakage test results have been plotted in *Figure 6* for the National Semiconductor 8A and 16A series of rectifiers (FRP820 and FRP1620 respectively) at 100°C, 125°C and 150°C. These points indicate that the low current injection level lifetime ranges from 20 ns–30 ns and is relatively independent of T_J. Since reliability design guidelines specify that the rectifiers be operated at one-half their voltage rating and 25°C–50°C below their maximum junction temperature, the expected leakage currents in well designed power supplies will run less than 1 mA.

REVERSE RECOVERY LOSSES

All pn-junction rectifiers, operating in the forward direction, store charge in the form of excess minority carriers. The amount of stored charge is proportional to the magnitude of the forward current. The process by which a rectifier diode is brought out of conduction and returned to its block state is called commutation. *Figure 7* shows an expanded view of current commutation, also called reverse recovery. Starting at time t_0, the rectifier is switched from its forward conducting state at a specified current ramp rate ($-dI_F/d_t$). The current ramp rate will be determined by the external circuit (E/L) or the turn-on time of a transistor switch. During the time t_1-t_2, the store charge within the rectifier is able to supply more current than the circuit requires, so that the rectifier behaves like a short circuit. Stored charge is depleted both by the reverse recovery current and recombination within the rectifier. Eventually the stored charge dwindles to the point that a depletion region around the junction starts to grow, allowing the rectifier to regain its reverse blocking voltage capability (t_2). From a circuit-design standpoint, the most important parameters are the peak reverse recovery current and "S", the softness factor. A "snappy" rectifier will produce a large amplitude voltage transient and contribute significantly to electro-magnetic interference. *Figure 8* illustrates the actual reverse recovery of two rectifier diodes. The peak voltage of the snappy rectifier is 175V compared to 142V peak for the FRP820, the higher voltage resulting from both the higher $I_{R(REC)}$ and the fact that the reverse recovery current decays to zero in a shorter time.

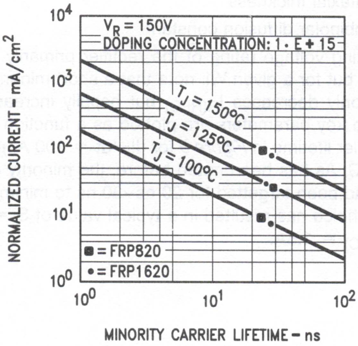

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FIGURE 6. Regeneration Current for Gold-Doped, P + N − N+ Rectifier Diodes

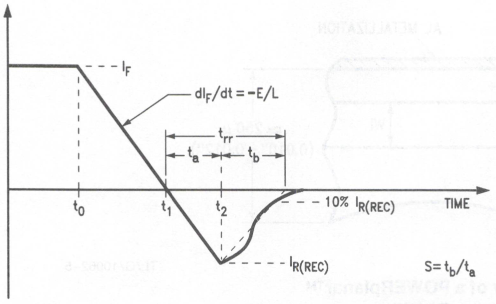

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FIGURE 7. Expanded View of Current Commutation in a Rectifier Diode

The relative snappiness of a rectifier may be defined quantitatively by dividing the reverse recovery time t_{rr} into two subperiods, t_a and t_b, as shown in *Figure 7*. The softness factor "S" is simply the ratio t_b/t_a. A rectifier with a low value S factor will be more likely to produce dangerous voltage transients, but it will also dissipate less reverse recovery energy than a high S factor rectifier. A reasonable compromise between these two conflicting constraints would be to design a rectifier with $S = 1$ ($t_a = t_b$). The S factors of the FRP820 rectifier and the competitive device in *Figure 8* are 0.55 and 0.31 respectively.

Only recently has it become possible to model the ramp recovery in p-i-n rectifiers (References 2, 3) and the following equations have proved useful in predicting reverse recovery parameters.

$$t_{rr} = \frac{Wi\sqrt{\tau/Da}}{8}$$

$$S = \frac{Wi}{4\sqrt{Da\tau}}$$

$$I_{R(REC)} = \left(\frac{dI_F}{dt}\right)\tau\left(1 + \frac{Wi}{8\sqrt{Da\tau}}\right) - 1$$

$$Q_{R(REC)} = 0.5\,\tau^2\left(\frac{dI_F}{dt}\right)$$

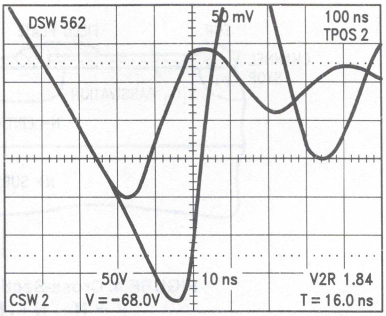
where:

τ = minority carrier lifetime

Wi = epitaxial thickness

Da = ambipolar diffusion constant

The blocking voltage rating of the rectifier primarily determines Wi; but for a given Wi, note that a short minority lifetime not only decreases $I_{R(REC)}$ but happily increases S. These two key parameters are plotted as a function of minority carrier lifetime in *Figure 9* for $dI_F/dt = 100\ A/\mu s$ and $T_J = 25°C$. As has been noted before, the minority carrier lifetime had been targetted for 20 ns–30 ns to minimize V_F and this choice has resulted in a typical value of $S = 0.65$ and $I_{R(REC)} = 1.5A$.



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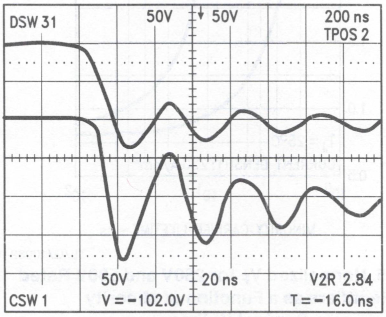
Test Conditions:

$T_j = 25°C$
$I_F = 8A$
$dI_F/dt = 100\ A/\mu S$
I = 0.5 A/DIV
T = 10 ns/DIV



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Test Conditions:

$T_j = 25°C$
$I_F = 8A$
$dI_F/dt = 100\ A/\mu s$
I = 50 VA/DIV
T = 10 ns/DIV

FIGURE 8. Comparison of Reverse Recovery of the FRP820 Series Rectifier to a Snappy Rectifier

REVERSE RECOVERY CHARACTERIZATION

Figures 10–13 plot $Q_{R(REC)}$, $I_{R(REC)}$, t_{rr} and S versus dI_F/dt for the FRP1600 series of rectifiers and typical use conditions of $I_F = 16A$ and $V_R = 200V$ and for two different junction temperatures of 25°C and 125°C. Theory not only predicts, but it has also been experimentally verified, that these parameters are relatively independent of I_F so only one value of the latter suffices. Any three of the four *Figures 10–13* completely specifies the reverse recovery behavior of the rectifier. Since S and T_{rr} vary the least over the plotting dI_F/dt range, it is convenient to formulate reverse recovery energy loss P in microwatts in terms of the circuit parameters V_R and dI_F/dt:

$$P = \frac{V_R\left(\frac{dI_F}{dt}\right)f}{2S}\left(\frac{St_{rr}}{1 + S}\right)^2 10^{-3}\ (\mu W)$$

where:

V_R = peak reverse voltage

dI_F/dt = ramp rate (A/μs)

f = operating frequency (kHz)

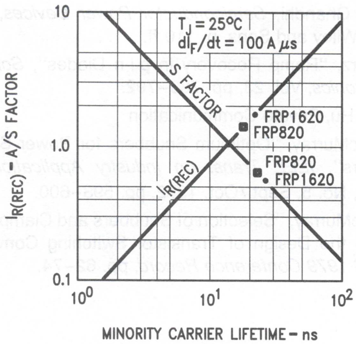

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FIGURE 9. Theoretical Plots of $I_{R(REC)}$ and S vs Minority Carrier Lifetime

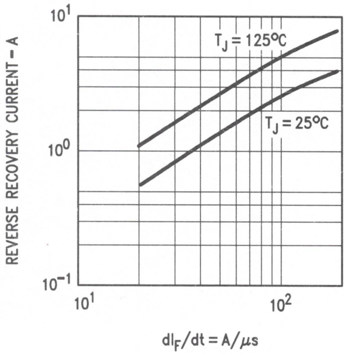

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FIGURE 10. Reverse Recovery Current for the FRM/FRP1620 Series Rectifiers

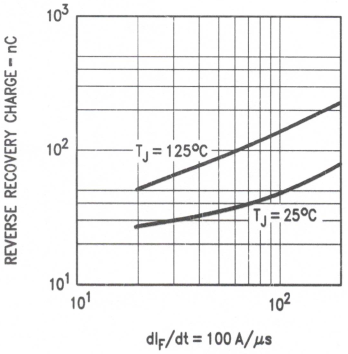

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FIGURE 11. Reverse Recovery Charge for the FRM/FRP1600 Series Rectifier Diodes

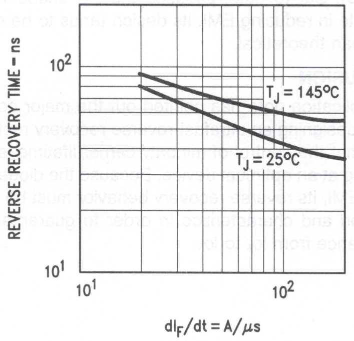

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FIGURE 12. Reverse Recovery Time of the FRM/FRP1600 Series Rectifier Diodes

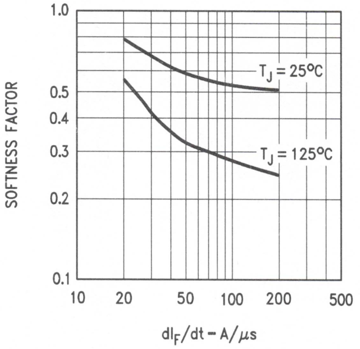

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FIGURE 13. Softness Factor S for the FRM/FRP1600 Series Rectifier Diodes

Example: Calculate the reverse recovery power loss for the FRP1620 rectifier running at:

$I_F = 16A$ $V_R = 100V$

$dI_F/dt = 100\ A/\mu s$ $T_J = 125°C$

$f = 75\ kHz$

From *Figures 12* and *13* $t_{rr} = 56$ ns and $S = 0.29$. Substituting these values in the above equation:

$$P = \frac{(100V)\ (100\ A/\mu s)(75\ kHz)}{(2)(0.29)} \left[\frac{(0.29)(56\ ns)}{1 + 0.29}\right]^2 10^{-3}\ \mu W$$

$P = 0.205W$

There are may ways to shape the reverse recovery voltage spike. The most simple and still most popular is the RC snubber circuit connected across the primary of the transformer in *Figure 1b*. This serves the dual purpose of suppressing voltage ringing and EMI due to the switching action of both the transistor and rectifier. William McMurray has shown how to design an RC snubber to minimize voltage transients and/or dV/dt ramps just due to the diode reverse recovery current (Reference 4) and also how to design snubbers to minimize transistor power dissipation (Reference 5). But to date, because the RC snubber plays a major role in reducing EMI, its design tends to be empirical rather than theoretical.

CONCLUSION

This application note has pointed out the major considerations in designing an ultrafast reverse recovery rectifier and shown that the control of minority carrier lifetime is the key in arriving at an optimum device. Because the diode contributes to EMI, its reverse recovery behavior must be carefully controlled and characterized in order to guarantee similar performance from lot to lot.

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1. S. K. Ghandhi, *Semiconductor Power Devices*, (NYC), John Wiley and Sons, p. 110 ff.
2. F. Berz, "Ramp Recovery in p-i-n Diodes", *Solid-State Electronics*, Vol. 23, pp. 783–792.
3. C. M. Hu, Private Communication
4. W. McMurray, "Optimum Snubbers for Power Semiconductors", *IEEE Trans. on Industry Applications*, Vol. 1A–8, No. 5, Sept./Oct. 1972, pp. 593–600.
5. W. McMurray, "Selection of Snubbers and Clamps to Optimize the Design of Transistor Switching Converters", *PESC 1979 Conference Record*, pp. 62–74.

Introduction to Power MOSFETs and Their Applications

National Semiconductor
Application Note 558
Ralph Locher

INTRODUCTION

The high voltage power MOSFETs that are available today are N-channel, enhancement-mode, double diffused, Metal-Oxide-Silicon, Field Effect Transistors. They perform the same function as NPN, bipolar junction transistors except the former are voltage controlled in contrast to the current controlled bi-polar devices. Today MOSFETs owe their ever-increasing popularity to their high input impedance and to the fact that being a majority carrier device, they do not suffer from minority carrier storage time effects, thermal runaway, or second breakdown.

MOSFET OPERATION

An understanding of the operation of MOSFETs can best be gleaned by first considering the later MOSFET shown in *Figure 1*.

With no electrical bias applied to the gate G, no current can flow in either direction underneath the gate because there will always be a blocking PN junction. When the gate is forward biased with respect to the source S, as shown in *Figure 2*, the free hole carriers in the p-epitaxial layer are repelled away from the gate area creating a channel, which allows electrons to flow from the source to the drain. Note that since the holes have been repelled from the gate channel, the electrons are the "majority carriers" by default. This mode of operation is called "enhancement" but it is easier to think of enhancement mode of operation as the device being "normally off", i.e., the switch blocks current until it receives a signal to turn on. The opposite is depletion mode, which is a normally "on" device.

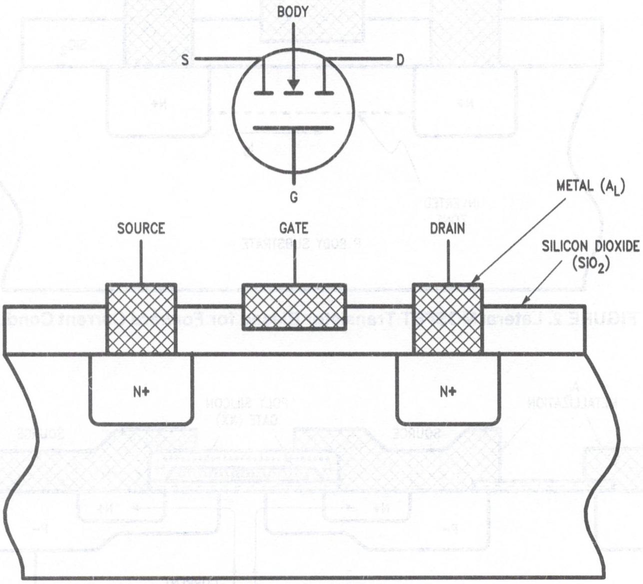

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FIGURE 1. Lateral N-Channel MOSFET Cross-Section

The advantages of the lateral MOSFET are:

1. Low gate signal power requirement. No gate current can flow into the gate after the small gate oxide capacitance has been charged.
2. Fast switching speeds because electrons can start to flow from drain to source as soon as the channel opens. The channel depth is proportional to the gate volage and pinches closed as soon as the gate voltage is removed, so there is no storage time effect as occurs in bipolar transistors.

The major disadvantages are:

1. High resistance channels. In normal operation, the source is electrically connected to the substrate. With no gate bias, the depletion region extends out from the N+ drain in a pseudo-hemispherical shape. The channel length L cannot be made shorter than the minimum depletion width required to support the rated voltage of the device.
2. Channel resistance may be decreased by creating wider channels but this is costly since it uses up valuable silicon real estate. It also slows down the switching speed of the device by increasing its gate capacitance.

Enter vertical MOSFETs!

The high voltage MOSFET structure (also known as DMOS) is shown in *Figure 3*.

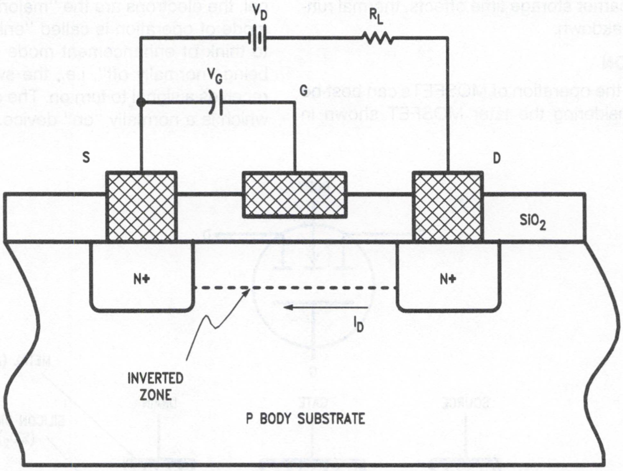
V_D
R_L
V_G
G
S
D
SiO_2
N+
N+
I_D
INVERTED ZONE
P BODY SUBSTRATE

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FIGURE 2. Lateral MOSFET Transistor Biased for Forward Current Conduction

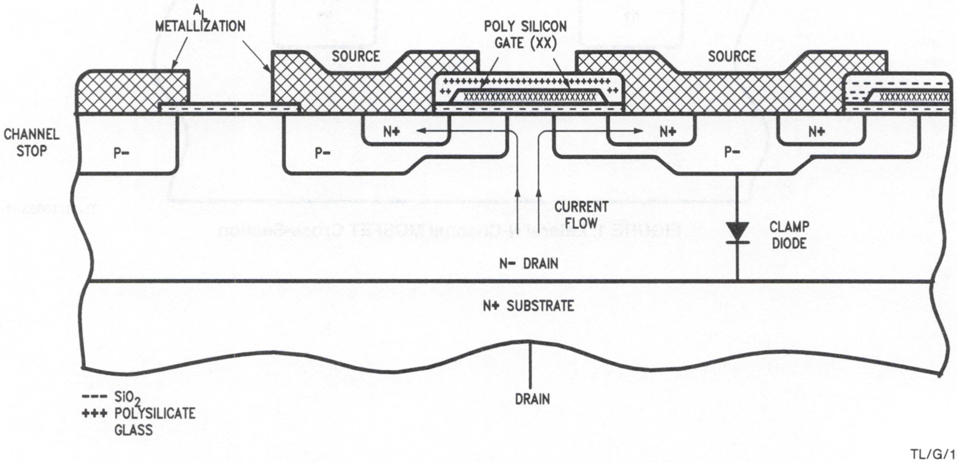
A_L METALLIZATION
POLY SILICON GATE (XX)
SOURCE
SOURCE
CHANNEL STOP
P−
P−
N+
N+
P−
N+
CURRENT FLOW
CLAMP DIODE
N− DRAIN
N+ SUBSTRATE
DRAIN
--- SiO_2
+++ POLYSILICATE GLASS

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FIGURE 3. Vertical DMOS Cross-Sectional View

The current path is created by inverting the p-layer underneath the gate by the identical method in the lateral FETs. Source current flows underneath this gate area and then vertically through the drain, spreading out as it flows down. A typical MOSFET consists of many thousands of N+ sources conducting in parallel. This vertical geometry makes possible lower on-state resistances ($R_{DS(on)}$) for the same blocking voltage and faster switching than the lateral FET.

There are many vertical construction designs possible, e.g., V-groove and U-groove, and many source geometries, e.g., squares, triangles, hexagons, etc. All commercially available power MOSFETs with blocking voltages greater than 300V are manufactured similarly to *Figure 3*. The many considerations that determine the source geometry are $R_{DS(on)}$, input capacitance, switching times and transconductance.

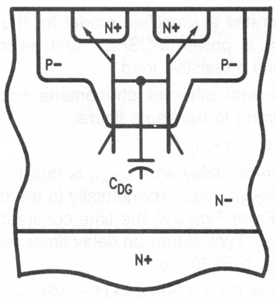
PARASITIC DIODE

Early versions of MOSFETs were very susceptible to voltage breakdown due to voltage transients and also had a tendency to turn on under high rates of rise of drain-to-source voltage (dV/dt), both resulting in catastrophic failures. The dV/dt turn-on was due to the inherent parasitic NPN transistor incorporated within the MOSFET, shown schematically in *Figure 4a*. Current flow needed to charge up junction capacitance C_{DG} acts like base current to turn on the parasitic NPN.

The parasitic NPN action is suppressed by shorting the N+ source to the P+ body using the source metallization. This now creates an inherent PN diode in anti-parallel to the MOSFET transistor (see *Figure 4b*). Because of its extensive junction area, the current ratings and thermal resistance of this diode are the same as the power MOSFET. This parasitic diode does exhibit a very long reverse recovery time and large reverse recovery current due to the long minority carrier lifetimes in the N-drain layer, which precludes the use of this diode except for very low frequency applications, e.g., motor control circuit shown in *Figure 5*. However in high frequency applications, the parasitic diode must be paralleled externally by an ultra-fast rectifier to ensure that the parasitic diode does not turn on. Allowing it to turn on will substantially increase the device power dissipation due to the reverse recovery losses within the diode and also leads to higher voltage transients due to the larger reverse recovery current.

CONTROLLING THE MOSFET

A major advantage of the power MOSFET is its very fast switching speeds. The drain current is strictly proportional to gate voltage so that the theoretically perfect device could switch in 50 ps–200 ps, the time it takes the carriers to flow from source to drain. Since the MOSFET is a majority carrier device, a second reason why it can outperform the bipolar junction transistor is that its turn-off is not delayed by minority carrier storage time in the base. A MOSFET begins to turn off as soon as its gate voltage drops down to its threshold voltage.



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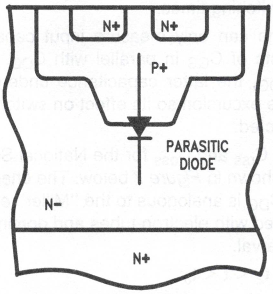
a. MOSFET Transistor Construction Showing Location of the Parasitic NPN Transistor



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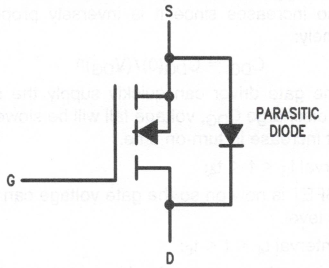
b. Parastic Diode



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c. Circuit Symbol
FIGURE 4

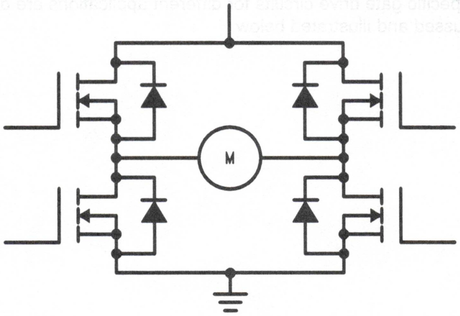

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FIGURE 5. Full-Wave Motor Control Circuit

SWITCHING BEHAVIOR

Figure 6 illustrates a simplified model for the parasitic capacitances of a power MOSFET and switching voltage waveforms with a resistive load.

There are several different phenomena occurring during turn-on. Referring to the same figure:

Time interval $t_1 < t < t_2$:

The initial turn-on delay time $t_{d(on)}$ is due to the length of time it takes V_{GS} to rise exponentially to the threshold voltage $V_{GS(th)}$. From *Figure 6*, the time constant can be seen to be $R_S \times C_{GS}$. Typical turn-on delay times for the National Semiconductor IRF330 are:

$$t_{d(on)} = R_S \times C_{GS} \times \ln\left(1 - V_{GS(th)}/V_{PK}\right)$$

For an assumed gate signal generator impedance of R_S of 50Ω and C_{GS} of 600 pF, t_d comes to 11 ns. Note that since the signal source impedance appears in the t_d equation, it is very important to pay attention to the test conditions used in measuring switching times.

Physically one can only measure input capacitance C_{iss}, which consists of C_{GS} in parallel with C_{DG}. Even though $C_{GS} >> C_{DG}$, the latter capacitance undergoes a much larger voltage excursion so its effect on switching time cannot be neglected.

Plots of C_{iss}, C_{rss} and C_{oss} for the National Semiconductor IRF330 are shown in *Figure 7* below. The charging and discharging of C_{DG} is analogous to the "Miller" effect that was first discovered with electron tubes and dominates the next switching interval.

Time interval $t_2 < t < t_3$:

Since V_{GS} has now achieved the threshold value, the MOSFET begins to draw increasing load current and V_{DS} decreases. C_{DG} must not only discharge but its capacitance value also increases since it is inversely proportional to V_{DG}, namely:

$$C_{DG} = C_{DG}(0)/(V_{DG})^n \tag{2}$$

Unless the gate driver can quickly supply the current required to discharge C_{DG}, voltage fall will be slowed with the attendant increase in turn-on time.

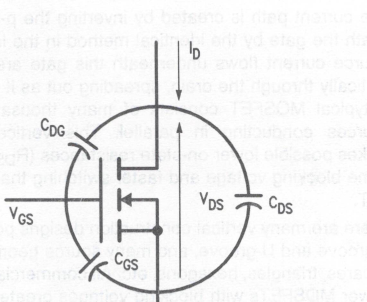
Time interval $t_3 < t < t_4$:

The MOSFET is now on so the gate voltage can rise to the overdrive level.

Turn-off interval $t_4 < t < t_6$:

Turn-off occurs in reverse order. V_{GS} must drop back close to the threshold value before R_{DS}(on) will start to increase. As V_{DS} starts to rise, the Miller effect due to C_{DG} re-occurs and impedes the rise of V_{DS} as C_{DG} recharges to V_{CC}.

Specific gate drive circuits for different applications are discussed and illustrated below.



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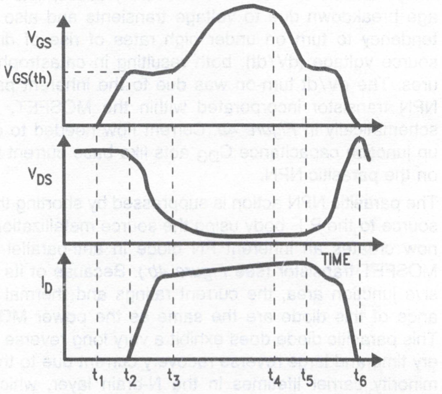
a. MOSFET Capacitance Model for Power MOSFET



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b. Switching Waveforms for Resistive Load

FIGURE 6

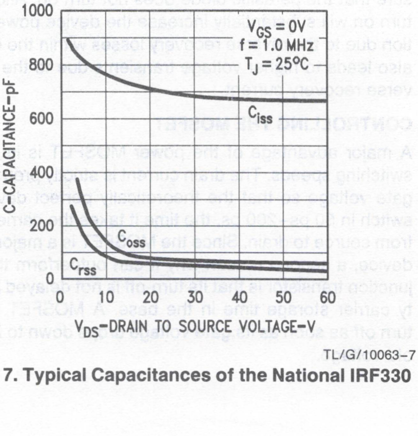

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FIGURE 7. Typical Capacitances of the National IRF330

MOSFET CHARACTERIZATION

The output characteristics (I_D vs V_{DS}) of the National Semiconductor IRF330 are illustrated in *Figures 8* and *9*.

The two distinct regions of operation in *Figure 8* have been labeled "linear" and "saturated". To understand the difference, recall that the actual current path in a MOSFET is horizontal through the channel created under the gate oxide and then vertical through the drain. In the linear region of operation, the voltage across the MOSFET channel is not sufficient for the carriers to reach their maximum drift velocity or their maximum current density. The static $R_{DS(on)}$, defined simply as V_{DS}/I_{DS}, is a constant.

As V_{DS} is increased, the carriers reach their maximum drift velocity and the current amplitude cannot increase. Since the device is behaving like a current generator, it is said to have high output impedance. This is the so-called "saturation" region. One should also note that in comparing MOSFET operation to a bipolar transistor, the linear and saturated regions of the bipolar are just the opposite to the MOSFET. The equal spacing between the output I_D curves for constant steps in V_{GS} indicates that the transfer characteristic in *Figure 9* will be linear in the saturated region.

IMPORTANCE OF THRESHOLD VOLTAGE

Threshold voltage $V_{GS(th)}$ is the minimum gate voltage that initiates drain current flow. $V_{GS(th)}$ can be easily measured on a Tektronix 576 curve tracer by connecting the gate to the drain and recording the required drain voltage for a specified drain current, typically 250 µA or 1 mA. ($V_{GS(th)}$ in *Figure 9* is 3.5V. While a high value of $V_{GS(th)}$, can apparently lengthen turn-on delay time, a low value for power MOSFET is undesirable for the following reasons:

1. $V_{GS(th)}$ has a negative temperature coefficient -7 mV/°C.
2. The high gate impedance of a MOSFET makes it susceptible to spurious turn-on due to gate noise.
3. One of the more common modes of failure is gate-oxide voltage punch-through. Low $V_{GS(th)}$ requires thinner oxides, which lowers the gate oxide voltage rating.

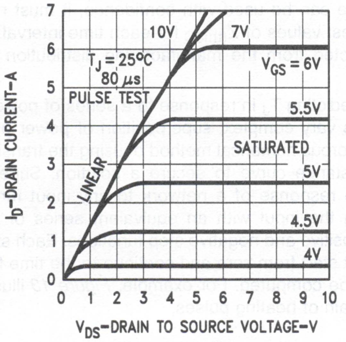

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FIGURE 8. Output Characteristics

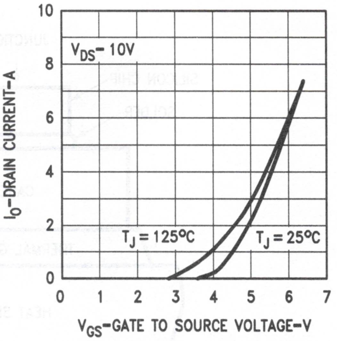

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FIGURE 9. Transfer Characteristics

POWER MOSFET THERMAL MODEL

Like all other power semiconductor devices, MOSFETs operate at elevated junction temperatures. It is important to observe their thermal limitations in order to achieve acceptable performance and reliability. Specification sheets contain information on maximum junction temperature ($T_{J(max)}$), safe areas of operation, current ratings and electrical characteristics as a function of T_J where appropriate. However, since it is still not possible to cover all contingencies, it is still important that the designer perform some junction calculations to ensure that the device operate within its specifications.

Figure 10 shows an elementary, stead-state, thermal model for any power semiconductor and the electrical analogue. The heat generated at the junction flows through the silicon pellet to the case or tab and then to the heat sink. The junction temperature rise above the surrounding environment is directly proportional to this heat flow and the junction-to-ambient thermal resistance. The following equation defines the steady state thermal resistance $R_{(th)JC}$ between any two points x and y:

$$R_{(th)JC} = (T_y - T_x)/P \qquad (3)$$

where:

T_x = average temperature at point x (°C)

T_y = average temperature at point y (°C)

P = average heat flow in watts.

Note that for thermal resistance to be meaningful, two temperature reference points must be specified. Units for $R_{(th)JC}$ are °C/W.

The thermal model show symbolically the locations for the reference points of junction temperature, case temperature, sink temperature and ambient temperature. These temperature reference define the following thermal references:

$R_{(th)JC}$: Junction-to-Case thermal resistance.

$R_{(th)CS}$: Case-to-Sink thermal resistance.

$R_{(th)SA}$: Sink-to-Ambient thermal resistance.

Since the thermal resistances are in series:

$$R_{(th)JA} = R_{(th)JC} + R_{(th)CS} + R_{(th)SA}. \qquad (4)$$

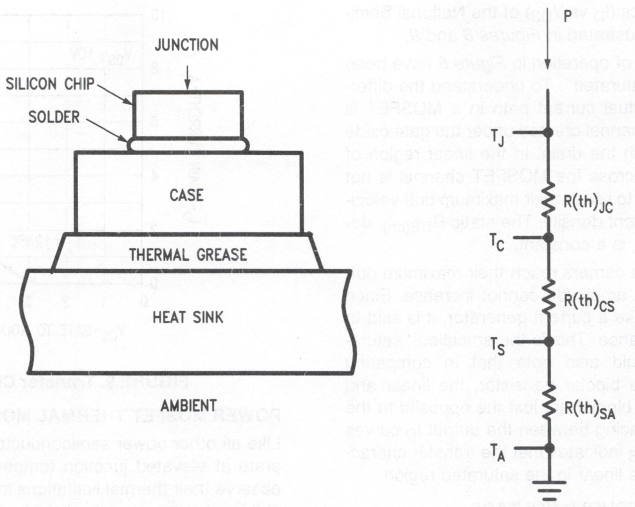

FIGURE 10. MOSFET Steady State Thermal Resistance Model

The design and manufacture of the device determines $R_{(th)JC}$ so that while $R_{(th)JC}$ will vary somewhat from device to device, it is the sole responsibility of the manufacturer to guarantee a maximum value for $R_{(th)JC}$. Both the user and manufacturer must cooperate in keeping $R_{(th)CS}$ to an acceptable maximum and finally the user has sole responsibility for the external heat sinking.

By inspection of *Figure 10*, one can write an expression for T_J:

$$T_J = T_A + Px\,[R_{(th)JC} + R_{(th)CS} + R_{(th)SA}] \tag{5}$$

While this appears to be a very simple formula, the major problem in using it is due to the fact that the power dissipated by the MOSFET depends upon T_J. Consequently one must use either an iterative or graphical solution to find the maximum $R_{(th)SA}$ to ensure stability. But an explanation of transient thermal resistance is in order to handle the case of pulsed applications.

Use of steady state thermal resistance is not satisfactory for finding peak junction temperatures for pulsed applications. Plugging in the peak power value results in overestimating the actual junction temperature while using the average power value underestimates the peak junction temperature value at the end of the power pulse. The reason for the discrepancy lies in the thermal capacity of the semiconductor and its housing, i.e., its ability to store heat and to cool down before the next pulse.

The modified thermal model for the MOSFET is shown in *Figure 11*. The normally distributed thermal capacitances have been lumped into single capacitors labeled C_J, C_C, and C_S. This simplification assumes current is evenly distributed across the silicon chip and that the only significant power losses occur in the junction. When a step pulse of heating power P is introduced at the junction, *Figure 12a* shows that T_J will rise at an exponential rate to some steady state value dependent upon the response of the thermal network. When the power input is terminated at time t_2, T_J will decrease along the curve indicated by T_{cool} in *Figure 12a* back to its initial value. Transient thermal resistance at time t is thus defined as:

$$Z_{(th)JC} = \frac{\Delta T_{JC}(t)}{P} \tag{6}$$

The transient thermal resistance curve approaches the steady state vaule at long times and the slope of the curve for short times is inversely proportional to C_J. In order that this curve can be used with confidence, it must represent the highest values of $Z_{(th)JC}$ for each time interval that can be expected from the manufacturing distribution of products.

While predicting T_J in response to a series of power pulses becomes very complex, superposition of power pulses offers a rigorous numerical method of using the transient thermal resistance curve to secure a solution. Superposition tests the response of a network to any input function by replacing the input with an equivalent series of superimposed positive and negative step functions. Each step function must start from zero and continue to the time for which T_J is to be computed. For example, *Figure 13* illustrates a typical train of heating pulses.

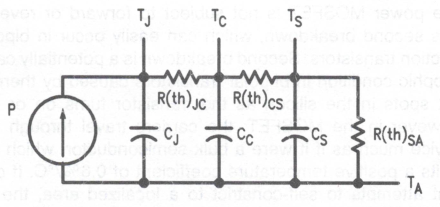

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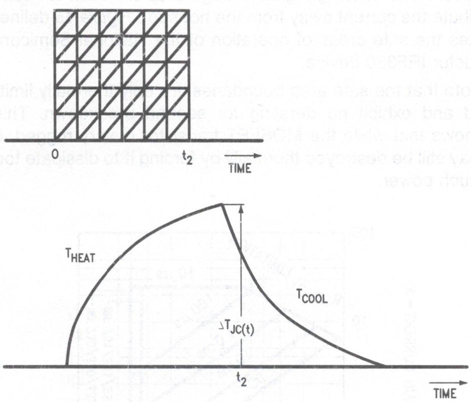
FIGURE 11. Transient Thermal Resistance Model



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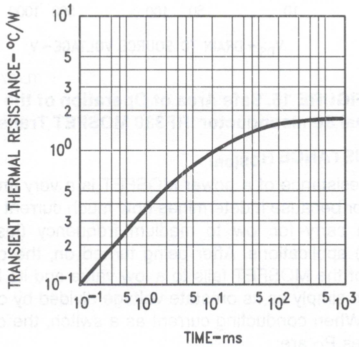
a. Junction Temperature Response to a Step Pulse of Heating Power



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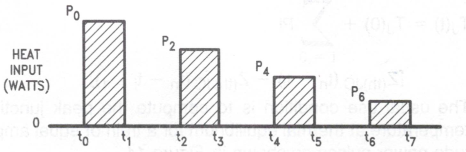
b. Transient Thermal Resistance Curve for National Semiconductor IRF330 MOSFET

FIGURE 12



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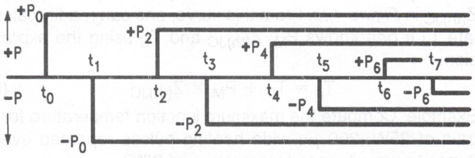
a. Heat Input



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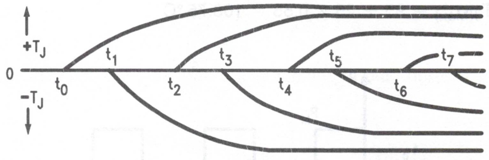
b. Equivalent Heat Input by Superposition of Power Pulses



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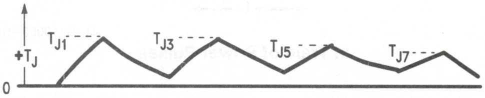
c. Junction Temperature Response to Individual Power Pulses of b



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d. Actual T_J

FIGURE 13. Use of Superposition to Determine Peak T_J

T_J at time t is given by:

$$T_J(t) = T_J(0) + \sum_{i=0}^{\eta} Pi \quad (7)$$

$$[Z_{(th)JC}(t_n - t_i) - Z_{(th)JC}(t_n - t_{i+1})]$$

The usual use condition is to compute the peak junction temperature at thermal equilibrium for a train of equal amplitude power pulses as shown in *Figure 14*.

To further simplify this calculation, the bracketed expression in equation (G) has been plotted for all National Semiconductor power MOSFETs, as exemplified by the plot of $Z_{(th)JC}$ in *Figure 14b*. From this curve, one can readily calculate T_J if one knows P_M, $Z_{(th)JC}$ and T_C using the expression:

$$T_J = T_C + P_M \times Z_{(th)JC} \quad (8)$$

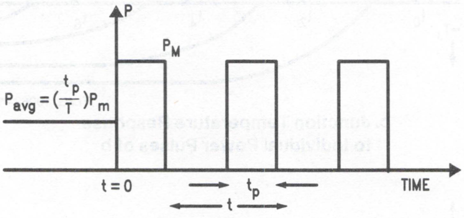
Example: Compute the maximum junction temperature for a train of 25W, 200 µs wide heating pulses repeated every 2 ms. Assume a case temperature of 95°C.

Duty factor = 0.1

From *Figure 14b:* $Z_{(th)JC} = 0.55°C/W$

Substituting into Equation (H):

$T_{J(Max)} = 95 + 25 \times 0.55 = 108.75\ °C$



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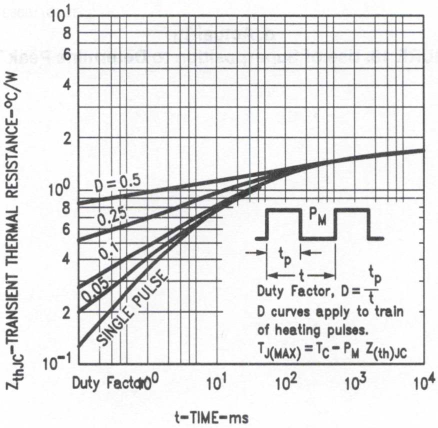
a. Train of Power Pulses



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b. Normalized $Z_{(th)JC}$ for National Semiconductor IRF330 for Power Pulses Typified in *Figure 14a*

FIGURE 14

SAFE AREA OF OPERATION

The power MOSFET is not subject to forward or reverse bias second breakdown, which can easily occur in bipolar junction transistors. Second breakdown is a potentially catastrophic condition in bi-polar transistors caused by thermal hot spots in the silicon as the transistor turns on or off. However in the MOSFET, the carriers travel through the device much as if it were a bulk semiconductor, which exhibits a positive temperature coefficient of 0.6%/°C. If current attempts to self-constrict to a localized area, the increasing temperature of the spot will raise the spot resistance due to the positive temperature coefficient of the bulk silicon. The ensuing higher voltage drop will tend to redistribute the current away from the hot spot. *Figure 15* delineates the safe areas of operation of the National Semiconductor IRF330 device.

Note that the safe area boundaries are only thermally limited and exhibit no derating for second breakdown. This shows that while the MOSFET transistor is very rugged, it may still be destroyed thermally by forcing it to dissipate too much power.

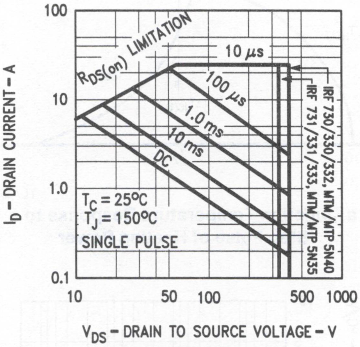

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FIGURE 15. Safe Area of Operation of the National Semiconductor IRF330 MOSFET Transistor

ON-RESISTANCE $R_{DS(on)}$

The on-resistance of a power MOSFET is a very important parameter because it determines how much current the device can carry for low to medium frequency (less than 200 kHz) applications. After being turned on, the on-state voltage of the MOSFET falls to a low value and its $R_{DS(on)}$ is defined simply as its on-state voltage divided by on-state current. When conducting current as a switch, the conduction losses P_C are:

$$P_C = I^2_{D(RMS)} \times R_{DS(on)} \quad (9)$$

To minimize $R_{DS(on)}$, the applied gate signal should be large enough to maintain operation in the linear or ohmic region as shown in *Figure 8*. All National Semiconductor MOSFETs will conduct their rated current for $V_{GS} = 10V$, which is also the value used to generate the curves of $R_{DS(on)}$ vs I_D and T_J that are shown in *Figure 16* for the National Semiconductor IRF330. Since $R_{DS(on)}$ increases with T_J, *Figure 16* plots this parameter as a function of current for room ambient and elevated temperatures.

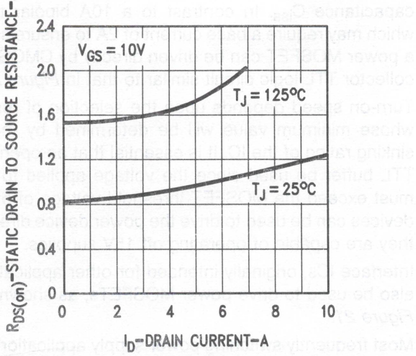

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FIGURE 16. $R_{DS(on)}$ of the National Semiconductor IRF330

Note that as the drain current rises, $R_{DS(on)}$ increases once I_D exceeds the rated current value. Because the MOSFET is a majority carrier device, the component of $R_{DS(on)}$ due to the bulk resistance of the N− silicon in the drain region increases with temperature as well. While this must be taken into account to avoid thermal runaway, it does facilitate parallel operation of MOSFETs. Any inbalance between MOSFETs does not result in current hogging because the device with the most current will heat up and the ensuing higher on-voltage will divert some current to the other devices in parallel.

TRANSCONDUCTANCE

Since MOSFETs are voltage controlled, it has become necessary to resurrect the term transconductance g_{fs}, commonly used in the past with electron tubes. Referring to *Figure 8*, g_{fs} equals the change in drain current divided by the change in gate voltage for a constant drain voltage. Mathematically:

$$g_{fs}\text{ (Siemens)} = \frac{dI_D(A)}{dV_{GS}(V)} \qquad (10)$$

Transconductance varies with operating conditions, starting at 0 for $V_{GS} < V_{GS(th)}$ and peaking at a finite value when the device is fully saturated. It is very small in the ohmic region because the device cannot conduct any more current. Typically g_{fs} is specified at half the rated current and for V_{DS} = 20V. Transconductance is useful in designing linear amplifiers and does not have any significance in switching power supplies.

GATE DRIVE CIRCUITS FOR POWER MOSFETs

The drive circuit for a power MOSFET will affect its switching behavior and its power dissipation. Consequently the type of drive circuitry depends upon the application. If on-state power losses due to $R_{DS(on)}$, will predominate, there is little point in designing a costly drive circuit. This power dissipation is relatively independent of gate drive as long as the gate-source voltage exceeds the threshold voltage by several volts and an elaborate drive circuit to decrease switching times will only create additional EMI and voltage ringing. In contrast, the drive circuit for a device switching at 200 kHz or more will affect the power dissipation since switching losses are a significant part of the total power dissipation.

Compare to a bi-polar junction transistor, the switching losses in a MOSFET can be made much smaller but these losses must still be taken into consideration. Examples of several typical loads along with the idealized switching waveforms and expressions for power dissipation are given in *Figures 17* to *19*.

Their power losses can be calculated from the general expression:

$$P_D = \left(\frac{1}{T}\int_0^T I_D(t) \bullet V_{DS}(t)dt\right) \bullet f_s \qquad (11)$$

where: f_s = Switching frequency.

For the idealized waveforms shown in the figures, the integration can be approximated by the calculating areas of triangles:

Resistive load:

$$P_D = \frac{V^2_{DD}}{R}\left[\frac{t_{(on)} + t_{(off)}}{6} + R_{DS(on)} \bullet T\right] \bullet f_s$$

Inductive load:

$$P_D = \frac{V_{CL}\, I_m\, t_{(off)} f_s}{2} + P_c$$

where:

P_C = conduction loss during period T.

Capacitive load:

$$P_D = \left(\frac{CV^2_{DD}}{2} + \frac{V^2_{DD}R_{DS(on)}}{R^2}\, T\right) f_s$$

Gate losses and blocking losses can usually be neglected. Using these equations, the circuit designer is able to estimate the required heat sink. A final heat run in a controlled temperature environment is necessary to ensure thermal stability.

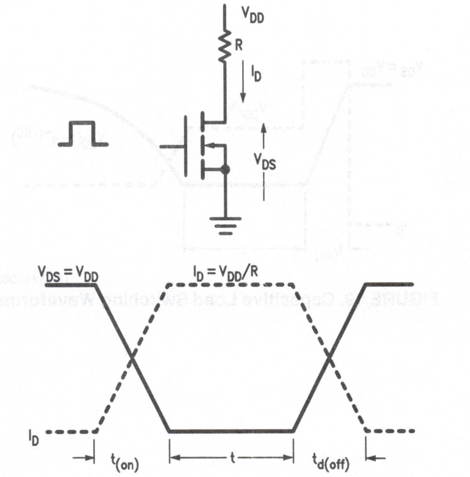

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FIGURE 17. Resistive Load Switching Waveforms

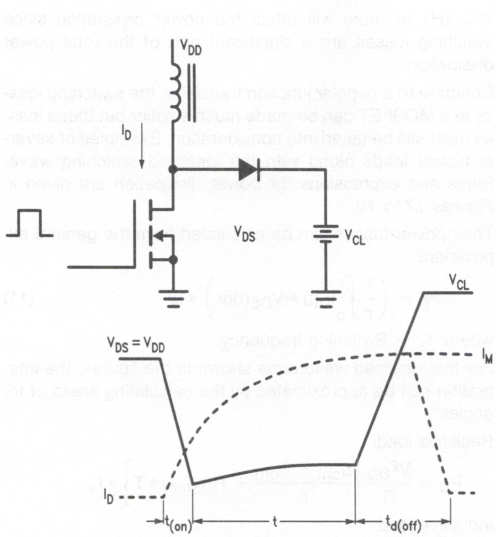

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FIGURE 18. Clamped Inductive Load Switching Waveforms

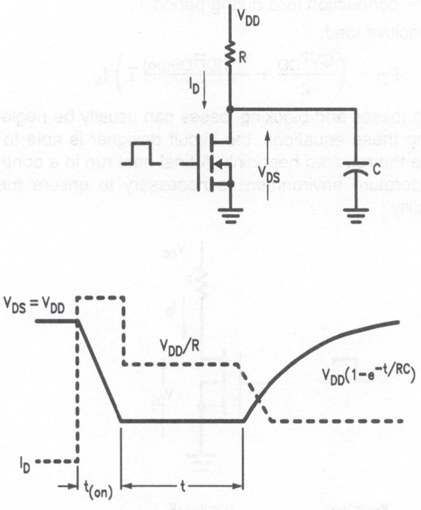

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FIGURE 19. Capacitive Load Switching Waveforms

Since a MOSFET is essentially voltage controlled, the only gate current required is that necessary to charge the input capacitance C_{iss}. In contrast to a 10A bipolar transistor, which may require a base current of 2A to ensure saturation, a power MOSFET can be driven directly by CMOS or open-collector TTL logic circuit similar to that in *Figure 20*.

Turn-on speed depends upon the selection of resistor R_1, whose minimum value will be determined by the current sinking rating of the IC. It is essential that an open collector TTL buffer be used since the voltage applied to the gate must exceed the MOSFET threshold voltage of 5V. CMOS devices can be used to drive the power device directly since they are capable of operating off 15V supplies.

Interface ICs, originally intended for other applications, can also be used to drive power MOSFETs, as shown below in *Figure 21*.

Most frequently switching power supply applications employ a pulse width modulator IC with an NPN transistor output stage. This output transistor is ON when the MOSFET should be ON, hence the type of drive used with open-collector TTL devices cannot be used. *Figures 22* and *23* give examples of typical drive circuits used with PWM ICs.

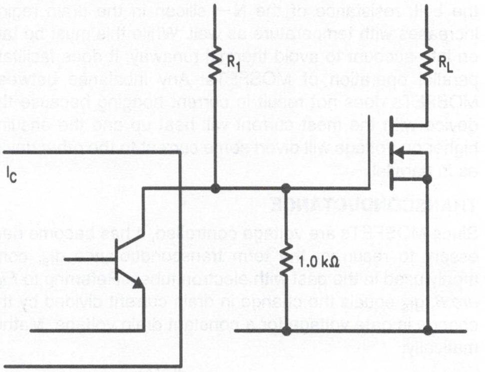

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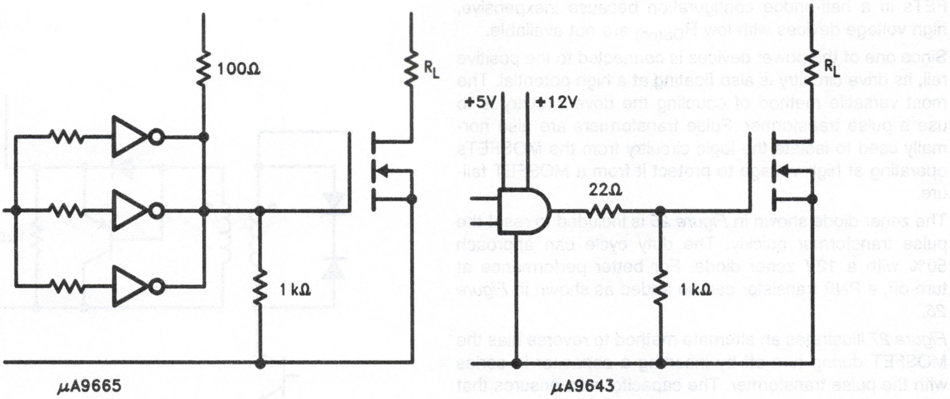
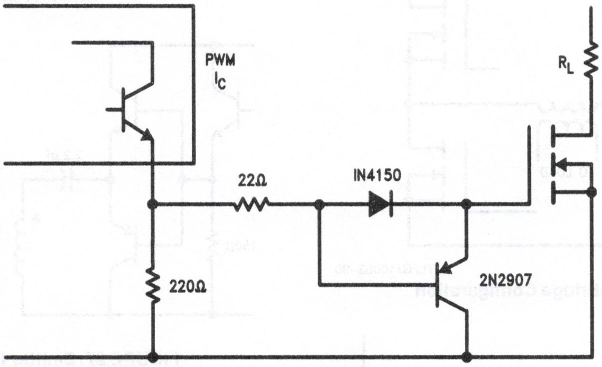
FIGURE 20. Open Collector TTL Drive Circuit


100Ω
RL
1 kΩ
µA9665
+5V
+12V
22Ω
RL
1 kΩ
µA9643

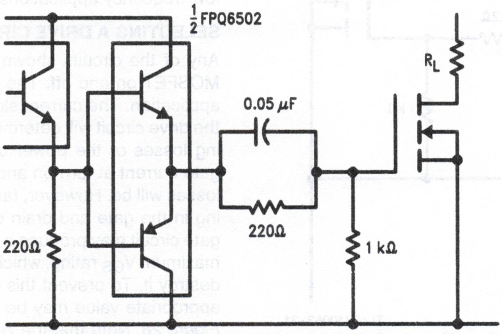
TL/G/10063-27

FIGURE 21. Interface ICs Used to Drive Power MOSFETs


PWM
IC
22Ω
IN4150
RL
220Ω
2N2907

TL/G/10063-28

FIGURE 22. Circuit for PWM IC Driving MOSFET. The PNP Transistor Speeds Up Turn-Off


$\frac{1}{2}$ FPQ6502
0.05 µF
RL
220Ω
220Ω
1 kΩ

TL/G/10063-29

FIGURE 23. Emitter Follower with Speed-Up Capacitor

Isolation: Off-line switching power supplies use power MOSFETs in a half-bridge configuration because inexpensive, high voltage devices with low $R_{DS(on)}$ are not available.

Since one of the power devices is connected to the positive rail, its drive circuitry is also floating at a high potential. The most versatile method of coupling the drive circuitry is to use a pulse transformer. Pulse transformers are also normally used to isolate the logic circuitry from the MOSFETs operating at high voltage to protect it from a MOSFET failure.

The zener diode shown in *Figure 25* is included to reset the pulse transformer quickly. The duty cycle can approach 50% with a 12V zener diode. For better performance at turn-off, a PNP transistor can be added as shown in *Figure 26*.

Figure 27 illustrates an alternate method to reverse bias the MOSFET during turn-off by inserting a capacitor in series with the pulse transformer. The capacitor also ensures that the pulse transformer will not saturate due to DC bias.

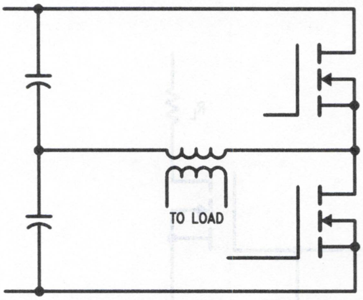


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FIGURE 24. Half-Bridge Configuration

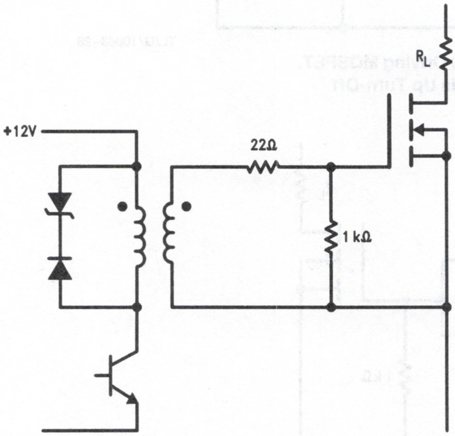

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FIGURE 25. Simple Pulse Transformer Drive Circuit. The Transistor May Be a Part of a PWM IC if Applicable.

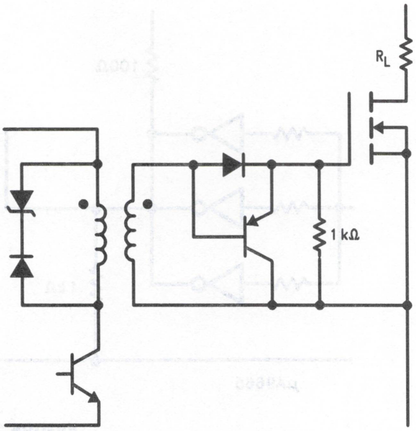

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FIGURE 26. Improved Performance at Turn-Off with a Transistor

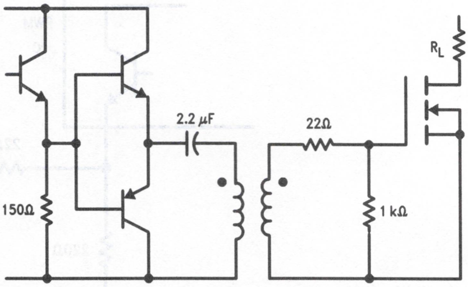

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FIGURE 27. Emitter Follower Driver with Speed-Up Capacitor

Opto-isolators may also be used to drive power MOSFETs but their long switching times make them suitable only for low frequency applications.

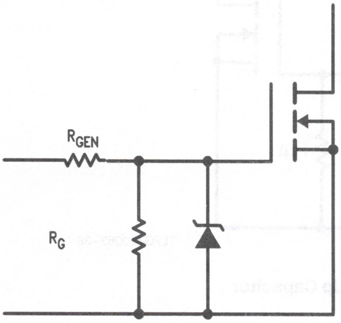
SELECTING A DRIVE CIRCUIT

Any of the circuits shown are capable of turning a power MOSFET on and off. The type of circuit depends upon the application. The current sinking and sourcing capabilities of the drive circuit will determine the switching time and switching losses of the power device. As a rule, the higher the gate current at turn-on and turn-off, the lower the switching losses will be. However, fast drive circuits may produce ringing in the gate and drain circuits. At turn-on, ringing in the gate circuit may produce a voltage transient in excess of the maximum V_{GS} rating, which will puncture the gate oxide and destroy it. To prevent this occurrence, a zener diode of the appropriate value may be added to the circuit as shown in *Figure 28*. Note that the zener should be mounted as close as possible to the device.

At turn-off, the gate voltage may ring back up to the threshold voltage and turn on the device for a short period. There is also the possibility that the drain-source voltage will exceed its maximum rated voltage due to ringing in the drain circuit. A protective RC snubber circuit or zener diode may be added to limit drain voltage to a safe level.

Figures 29–34 give typical turn-on and turn-off times of various drive circuits for the following test circuit:

Device: National Semiconductor IRF450, V_{DD} = 200V, Load = 33Ω resistor.



R_{GEN}
R_G
1N5250

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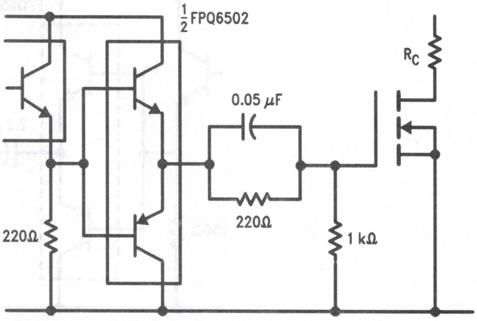
FIGURE 28. Zener Diode to Prevent Excessive Gate-Source Voltages

DRIVE CIRCUIT TURN-ON/TURN-OFF TIMES



$\frac{1}{2}$FPQ6502
R_C
0.05 μF
220Ω
220Ω
1 kΩ

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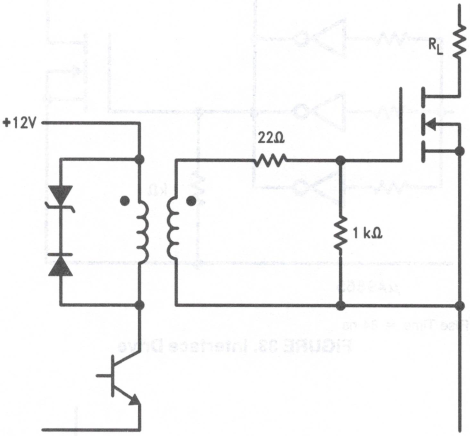
Note: Voltage Fall Time = 17 ns, Voltage Rise Time = 20 ns

FIGURE 29. Emitter Follower PWM



R_L
+12V
22Ω
1 kΩ

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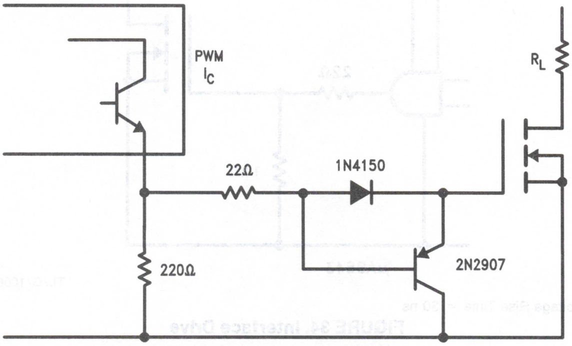
Note: Voltage Fall Time = 50 ns, Voltage Rise Time = 112 ns

FIGURE 30. Simple Pulse Transformer



PWM
I_C
R_L
22Ω
1N4150
2N2907
220Ω

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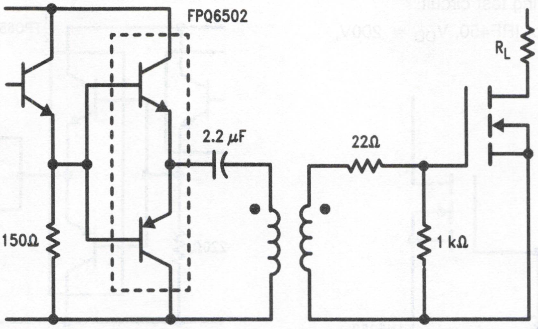
Note: Voltage Fall Time = 50 ns, Voltage Rise Time = 16 ns

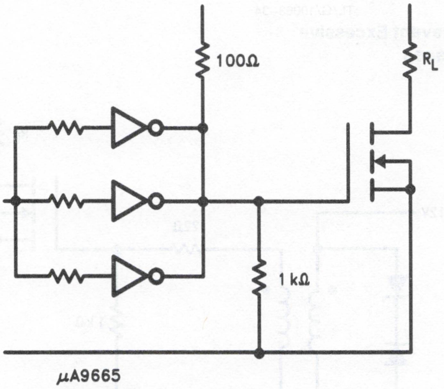
FIGURE 31. Pulse Width Modulator


FPQ6502
2.2 µF
150Ω
22Ω
1 kΩ
R_L

TL/G/10063-38

Note: Voltage Fall Time = 63 ns, Voltage Rise Time = 74 ns

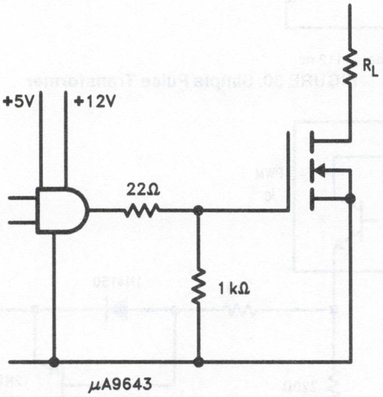
FIGURE 32. Pulse Transformer with Speed-Up Capacitor


100Ω
R_L
1 kΩ
µA9665

TL/G/10063-39

Note: Voltage Fall Time = 200 ns, Voltage Rise Time = 84 ns

FIGURE 33. Interface Drive


R_L
+5V
+12V
22Ω
1 kΩ
µA9643

TL/G/10063-40

Note: Voltage Fall Time = 70 ns, Voltage Rise Time = 30 ns

FIGURE 34. Interface Drive

Packaging Options and Ordering Information for Small Signal Diodes and Transistors

This brochure outlines the many packaging options for small signal discrete devices. The packaging options are:

A. Diode
   1. Bulk
   2. Tape and reel *(Figure 1)*

B. Transistor
   1. Bulk
   2. Tape and reel *(Figure 2)*
   3. Ammo pack *(Figure 3)*

C. Surface Mount devices—tape and reel *(Figure 4)*

D. Diode and transistor arrays in P-DIP or ceramic tubes.

E. SOIC transistor or diode arrays—tape and reel *(Figure 5)*

Ordering information for axial lead diodes.

No suffix indicates bulk packaging.

Package quantity: DO-35 = 2,000 min
DO-7 = 1,000 min

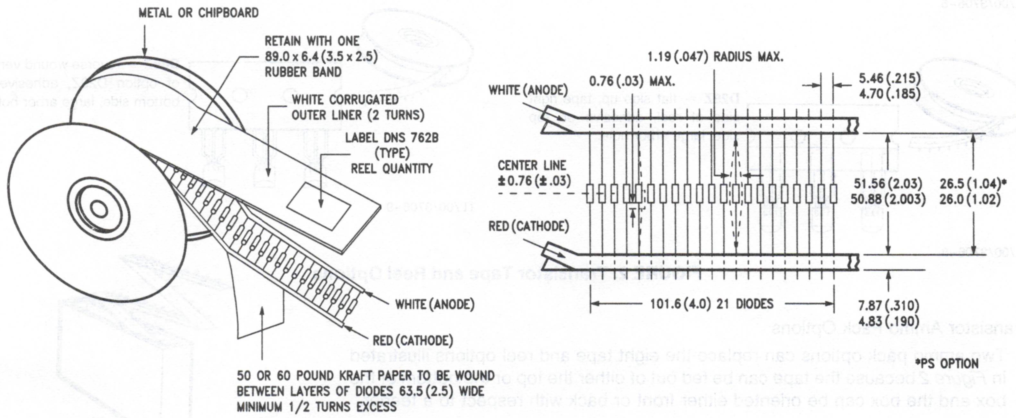
Package quantities for Zener Diodes: DO-35 = 5,000
DO-41 = 3,000

Ordering Information for Tape & Reel Options for Axial Lead Diodes

1. .TR suffix indicates axial Tape & Reel (50mm tape spacing) package. (Example: 1N4148.TR). See *Figure 1.*
2. .PS suffix indicates axial Tape & Reel (26mm tape spacing) package. (Example: 1N4148.PS). See *Figure 1.*

Reel quantities for .TR and .PS options:

Signal Diodes	Zener Diodes
DO-35 = 10,000	DO-35 = 5,000
DO-7 = 7,000	DO-41 = 3,000


METAL OR CHIPBOARD
RETAIN WITH ONE 89.0 x 6.4 (3.5 x 2.5) RUBBER BAND
WHITE CORRUGATED OUTER LINER (2 TURNS)
LABEL DNS 762B (TYPE) REEL QUANTITY
WHITE (ANODE)
RED (CATHODE)
50 OR 60 POUND KRAFT PAPER TO BE WOUND BETWEEN LAYERS OF DIODES 63.5 (2.5) WIDE MINIMUM 1/2 TURNS EXCESS
1.19 (.047) RADIUS MAX.
0.76 (.03) MAX.
5.46 (.215)
4.70 (.185)
WHITE (ANODE)
CENTER LINE ±0.76 (±.03)
RED (CATHODE)
51.56 (2.03)
50.88 (2.003)
26.5 (1.04)*
26.0 (1.02)
101.6 (4.0) 21 DIODES
7.87 (.310)
4.83 (.190)
*PS OPTION

TL/00/3706–1

FIGURE 1

Note: All dimensions in millimeters with inches in parenthesis.

Ordering information for transistors.

No suffix indicates bulk packaging. Package quantities are:

TO-18 = 500
TO-39 = 400
TO-92 = 2,000

Transistor Tape & Reel for TO-92

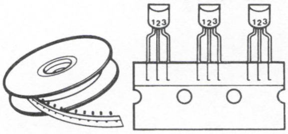
1. Choose the appropriate option from the eight listed in *Figure 2*.
2. Cost adders are applicable to these options. Ammo Pack is the most economical option available. Contact the local National Semiconductor sales office or franchised distributor for details.
3. Standard pack and minimum order quantities apply.

   A. Tape and Reel = 2,000 pieces.

   B. Ammo Pack = 2,000 pieces.

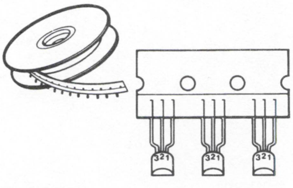
   Scheduled orders must be in multiples of 2,000.
4. Ordering example:

   2N3904/D26Z (flat side down, tape on left, large arbor hole)



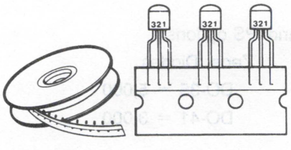
D26Z = flat side down, tape left side of reel, adhesive on top side, large arbor hole.

TL/00/3706-2



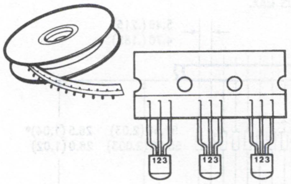
D28Z = flat side down, tape right side of reel, adhesive on top side, large arbor hole.

TL/00/3706-4



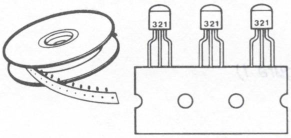
D27Z = flat side up, tape left side of reel, adhesive on top side, large arbor hole.

TL/00/3706-6



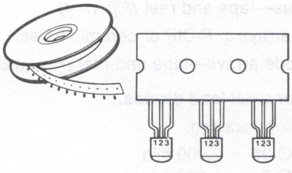
D29Z = flat side up, tape right side of reel, adhesive on top side, large arbor hole.

TL/00/3706-8



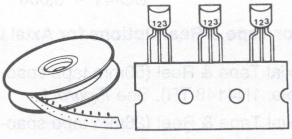
D11Z = reverse wound version of option D26Z, adhesive on bottom side, large arbor hole.

TL/00/3706-3



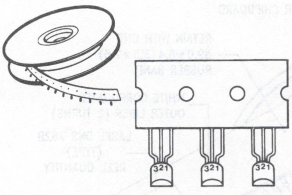
D10Z = reverse wound version of option D28Z, adhesive on bottom side, large arbor hole.

TL/00/3706-5



D81Z = reverse wound version of option D27Z, adhesive on bottom side, large arbor hole.

TL/00/3706-7



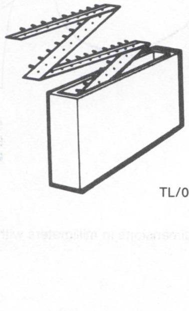
D89Z = reverse wound version of option D29Z, adhesive on bottom side, large arbor hole.

TL/00/3706-9

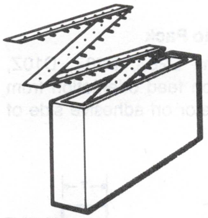
FIGURE 2. Transistor Tape and Reel Options

Transistor Ammo Pack Options

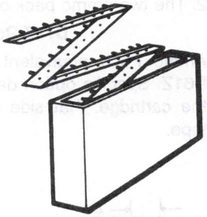
1. Two ammo pack options can replace the eight tape and reel options illustrated in *Figure 2* because the tape can be fed out of either the top or the bottom of the box and the box can be oriented either front or back with respect to a feeder.



TL/00/3706-11



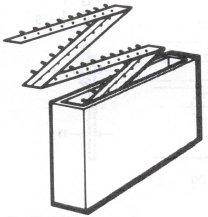
TL/00/3706-10



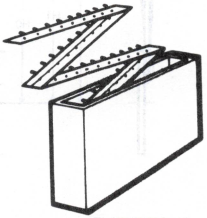
TL/00/3706-11

D75Z Radial Ammo Pack

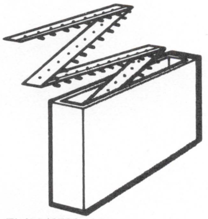
Ammo Pack equivalent to options D26Z, D28Z, D10Z, D11Z. Specific option dependent on feed orientation from the cartridge. Round side of transistor on adhesive side of tape.



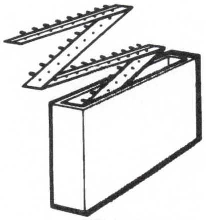
TL/00/3706-12



TL/00/3706-13



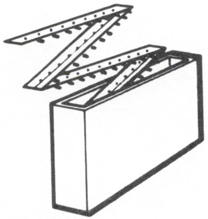
TL/00/3706-14



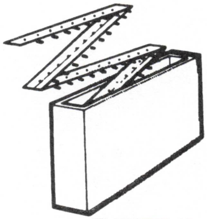
TL/00/3706-15

D74Z Radial Ammo Pack

Ammo Pack equivalent to options D27Z, D29Z, D89Z, D81Z. Specific option dependent on feed orientation from the cartridge. Flat side of transistor on adhesive side of tape.



TL/00/3706-16



TL/00/3706-17

The drawings show package TO-92 transistors, which is the most common product selected for tape and reel; however, the same information applies for other package styles, such as TO-237 and tall TO-92.

FIGURE 3. Transistor Ammo Pack Options

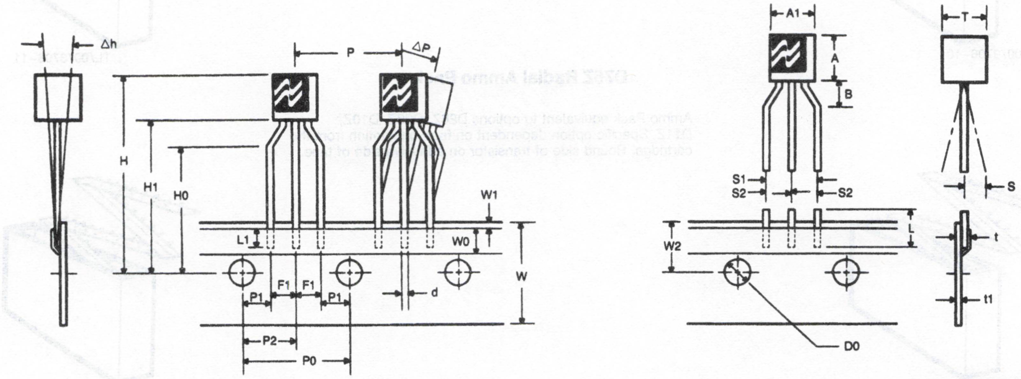
2. The two ammo pack options are:

D74Z Radial Ammo Pack

Ammo Pack equivalent to options D27Z, D29Z, D89Z, D61Z. Specific option dependent on feed orientation from the cartridge. Flat side of transistor on adhesive side of tape.

D75Z Radial Ammo Pack

Ammo Pack equivalent to options D26Z, D28Z, D10Z, D11Z. Specific option dependent on feed orientation from the cartridge. Round side of transistor on adhesive side of tape.



TL/00/3706–18

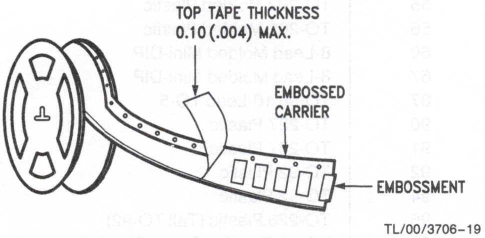
Symbol	MM Value (Min/Max)	Decimal Value (Min/Max)
A	3.2/9.0	0.126/0.354
A1	6.0 Max	0.236 Max
T	6.0 Max	0.236 Max
B	2.5 Max	0.098 Max
H	27.0/29.21	1.063/1.150
H0	15.5/16.5	0.610/0.650
H1	18.5/19.5	0.728/0.768
ΔP	±0.8	±0.031
Δh	±0.8	±0.031
P	12.2/13.2	0.480/0.520
P0	12.5/12.9	0.492/0.508
P1	3.55/4.04	0.140/0.159
P2	6.05/6.50	0.240/0.254
F1	2.4/2.6	0.094/0.102
d	0.45/0.55	0.018/0.022
L	10.9 Max	0.429 Max
L1	4.0/6.6	0.157/0.260
t	0.66/0.96	0.026/0.038
t1	0.38/0.68	0.015/0.027
W	17.5/18.5	0.689/0.728
W0	5.7/6.3	0.224/0.248
W1	0.5 Max	0.020 Max
W2	8.5/9.75	0.026/0.038
D0	3.8/4.2	0.150/0.165
S	±0.1	±0.004
S1	4.69/5.28	0.185/0.208
S2	2.36/2.62	0.093/0.103

*From tape center
**Spring after cut

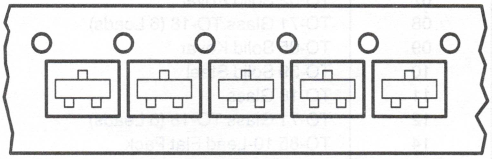
Surface Mount Diodes and Transistors in SOT-23/TO-236 package and LL-34 packages; (See *Figure 4*)

1. Transistors
   a. No suffix denotes low profile package (TO-236AB) on 7″ diameter reel. (Example: MMBT2222A) Reel quantity = 3,000
   b. Suffix -HIGH is used to order the profile package (TO-236AA) on 7″ diameter reel. (Example: MMBT2222A-HIGH) Reel quantity = 2,500
2. Diodes encapsulated in TO-236 package
   a. .SA suffix denotes high profile package (TO-236AA) on 7″ diameter reel. (Example: FDSO1201.SA). See *Figure 4.* Reel quantity = 2,500
   b. .LA suffix indicates low profile package (TO-236AB) on 7″ diameter reel. (Example: FDSO1201.LA). Reel quantity = 3,000
3. Leadless Diodes in LL-34 package

   Suffix characters .TR indicates 7″ diameter Tape & Reel (Example: FDLL4148.TR) See *Figure 6.* Reel quantity = 2,500
4. SOIC Packages (14-SOIC, 16-SOIC) See *Figure 5.*
   a. T suffix letter indicates a 7″ diameter reel with 700 devices. (Example: FSAO2509T)
   b. X suffix letter indicates a 13″ diameter reel with 2,500 devices. (Example: FSAO2509X)

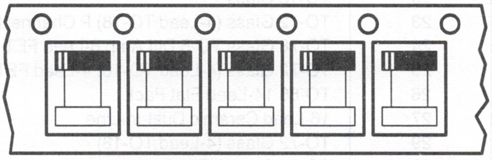

TOP TAPE THICKNESS
0.10 (.004) MAX.
EMBOSSED
CARRIER
EMBOSSMENT

TL/00/3706-19



TL/00/3706-20

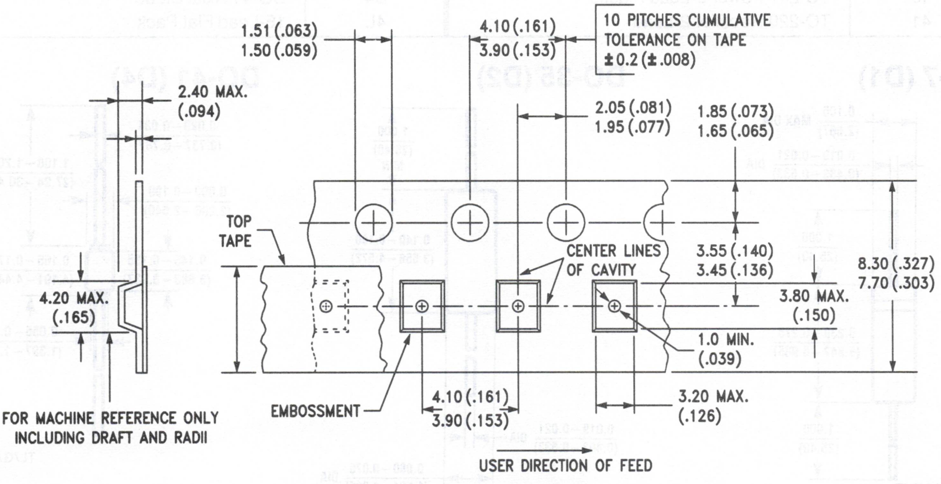
SOT-23 Style A



TL/00/3706-21

LL-34 Style A

FIGURE 4. TO-236 and LL-34 Taping Specification


1.51 (.063)
1.50 (.059)
4.10 (.161)
3.90 (.153)
10 PITCHES CUMULATIVE
TOLERANCE ON TAPE
±0.2 (±.008)
2.40 MAX.
(.094)
2.05 (.081)
1.95 (.077)
1.85 (.073)
1.65 (.065)
TOP
TAPE
CENTER LINES
OF CAVITY
3.55 (.140)
3.45 (.136)
8.30 (.327)
7.70 (.303)
4.20 MAX.
(.165)
3.80 MAX.
(.150)
1.0 MIN.
(.039)
4.10 (.161)
3.90 (.153)
3.20 MAX.
(.126)
EMBOSSMENT
FOR MACHINE REFERENCE ONLY
INCLUDING DRAFT AND RADII
USER DIRECTION OF FEED

TL/00/3706-22

FIGURE 5. SOIC Taping Specification

National Semiconductor

PACKAGE OUTLINES

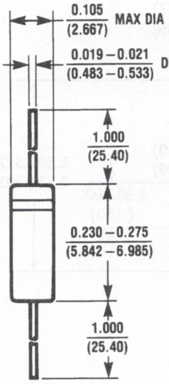
Dimensions are in $\frac{\text{inches}}{\text{(millimeters)}}$.

Numbers in parentheses behind package titles are NS internal package codes.

Dimensions and package codes shown are applicable at time of printing. Factory should be consulted to confirm dimensions, package codes, and other information given.

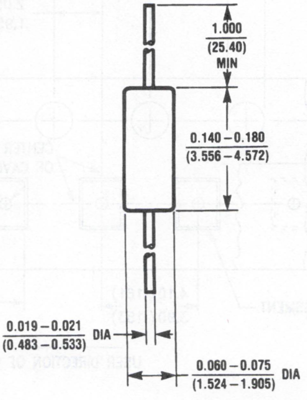
NS Package Code	JEDEC Code
01	TO-116 14-Lead Plastic DIP
02	TO-18 Glass
03	16-Lead Plastic DIP
04	TO-5 Glass
06	TO-46 Solid Kovar
07	TO-52 Solid Kovar
08	TO-71 Glass TO-18 (6 Leads)
09	TO-05 Solid Kovar
10	TO-39 Solid Steel
11	TO-18 Glass
12	TO-71 Glass TO-18 (6 Leads)
14	TO-85 10-Lead Flat Pack
17	TO-39 Solid Steel Low Profile
18	TO-52 Solid Kovar
19	TO-18 Glass
23	TO-72 Glass (4-Lead TO-18) P Channel FET
24	TO-78 Glass TO-5 Diff Amp 8-Lead FET
25	TO-72 Glass (4-Lead TO-18) 4-Lead FET
26	TO-86 14-Lead Flat Pack
27	16-Lead Ceramic Dual-In-Line
29	TO-72 Glass (4-Lead TO-18)
30	TO-78 Glass TO-5 (8 Leads)
35	TO-116-2 14-Lead DIP
37	TO-220 3-Lead
38	TO-220 Multiple Rectifier 3-Lead
39	TO-116 14-Lead Molded DIP
40	TO-247 Power 3-Lead Plastic
41	TO-220 Rectifier 2-Lead
42	TO-204 Power MOSFET 30 Mil Lead
43	TO-204 Power MOSFET 60 Mil Lead
44	TO-247 Rectifier 2-Lead Plastic
48	TO-236 (SOT-23) High Profile SMD
49	TO-236 (SOT-23) Standard Profile SMD
51	TO-202 Molded Plastic
55	TO-202 Molded Plastic
56	TO-202 Molded Plastic
60	8-Lead Molded Mini-DIP
67	8-Lead Molded Mini-DIP
87	TO-96 10-Lead TO-5
90	TO-237 Plastic
91	TO-237 Plastic
92	TO-92 Plastic
94	TO-92 Plastic
95	TO-226 Plastic (Tall TO-92)
96	TO-92 Faraday Shield Plastic
97	TO-92 Plastic
98	TO-92 Faraday Shield Plastic
99	TO-226 (Tall TO-92) Plastic
S1	SOIC 8-Lead SMD
S2	SOIC 14-Lead SMD
S3	SOIC 16-Lead SMD
D1	DO-7 Axial Diode
D2	DO-35 Axial Diode
D3	LL-34 Diode SMD
D4	DO-41 Axial Diode
4L	16-Lead Flat Pack

DO-7 (D1)


0.105 (2.667) MAX DIA
0.019 – 0.021 (0.483 – 0.533) DIA
1.000 (25.40)
0.230 – 0.275 (5.842 – 6.985)
1.000 (25.40)

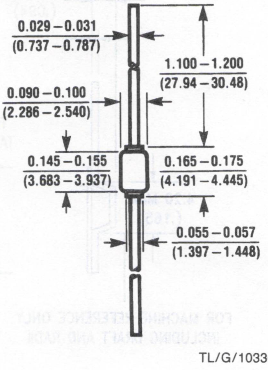
TL/G/10336–1

DO-35 (D2)


1.000 (25.40) MIN
0.140 – 0.180 (3.556 – 4.572)
0.019 – 0.021 (0.483 – 0.533) DIA
0.060 – 0.075 (1.524 – 1.905) DIA

TL/G/10336–2

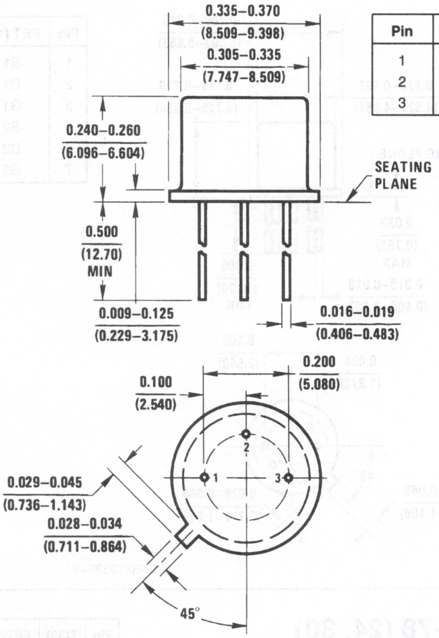
DO-41 (D4)


0.029 – 0.031 (0.737 – 0.787)
1.100 – 1.200 (27.94 – 30.48)
0.090 – 0.100 (2.286 – 2.540)
0.145 – 0.155 (3.683 – 3.937)
0.165 – 0.175 (4.191 – 4.445)
0.055 – 0.057 (1.397 – 1.448)

TL/G/10336–3

TO-5(04)

Pin	T
1	E
2	B
3	C

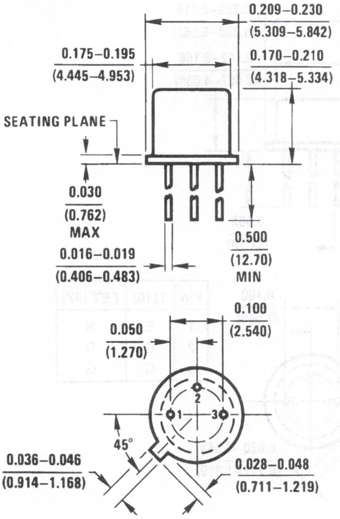

0.335–0.370
(8.509–9.398)
0.305–0.335
(7.747–8.509)
0.240–0.260
(6.096–6.604)
SEATING PLANE
0.500
(12.70)
MIN
0.009–0.125
(0.229–3.175)
0.016–0.019
(0.406–0.483)
0.200
(5.080)
0.100
(2.540)
2
1
3
0.029–0.045
(0.736–1.143)
0.028–0.034
(0.711–0.864)
45°

TL/G/10336-4

TO-18 (02, 11, 19)

Pin	T (02), (19)
1	E
2	B
3	C

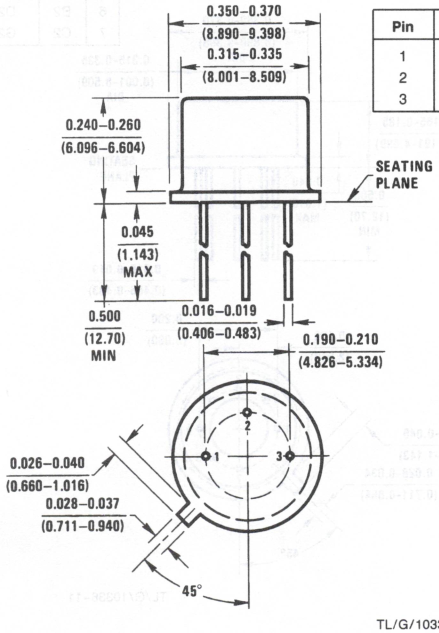
Pin	FET N(02)	FET P(11)
1	S	S
2	D	G
3	G	D


0.209–0.230
(5.309–5.842)
0.175–0.195
(4.445–4.953)
0.170–0.210
(4.318–5.334)
SEATING PLANE
0.030
(0.762)
MAX
0.016–0.019
(0.406–0.483)
0.500
(12.70)
MIN
0.100
(2.540)
0.050
(1.270)
2
1
3
45°
0.036–0.046
(0.914–1.168)
0.028–0.048
(0.711–1.219)

TL/G/10336-5

TO-39 (09, 10)

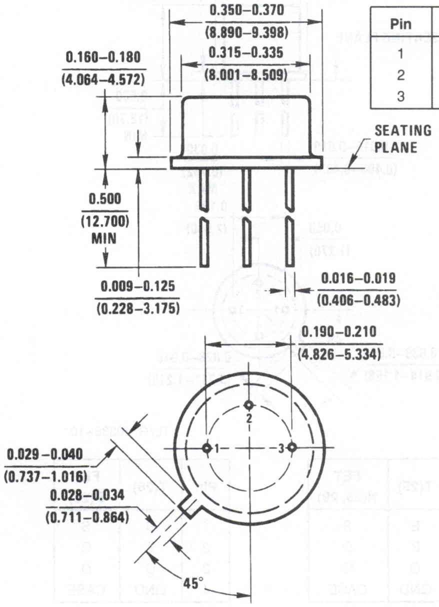
Pin	T
1	E
2	B
3	C


0.350–0.370
(8.890–9.398)
0.315–0.335
(8.001–8.509)
0.240–0.260
(6.096–6.604)
SEATING PLANE
0.045
(1.143)
MAX
0.500
(12.70)
MIN
0.016–0.019
(0.406–0.483)
0.190–0.210
(4.826–5.334)
2
1
3
0.026–0.040
(0.660–1.016)
0.028–0.037
(0.711–0.940)
45°

TL/G/10336-6

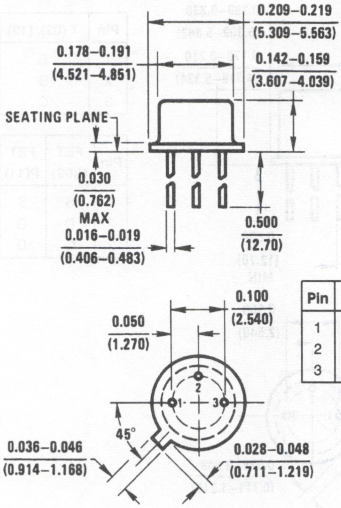
TO-39(17) Lo-Profile

Pin	T
1	E
2	B
3	C


0.350–0.370
(8.890–9.398)
0.315–0.335
(8.001–8.509)
0.160–0.180
(4.064–4.572)
SEATING PLANE
0.500
(12.700)
MIN
0.009–0.125
(0.228–3.175)
0.016–0.019
(0.406–0.483)
0.190–0.210
(4.826–5.334)
2
1
3
0.029–0.040
(0.737–1.016)
0.028–0.034
(0.711–0.864)
45°

TL/G/10336-7

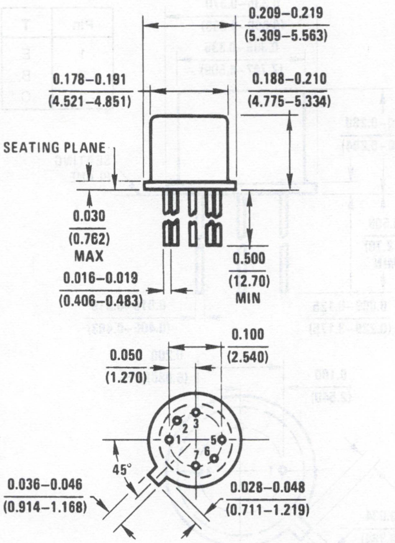
TO-52 (07, 18)


0.209–0.219
(5.309–5.563)
0.178–0.191
(4.521–4.851)
0.142–0.159
(3.607–4.039)
SEATING PLANE
0.030
(0.762)
MAX
0.016–0.019
(0.406–0.483)
0.500
(12.70)
0.100
(2.540)
0.050
(1.270)
2
1
3
45°
0.036–0.046
(0.914–1.168)
0.028–0.048
(0.711–1.219)

Pin	T(18)	FET (07)
1	E	S
2	B	D
3	C	G

TL/G/10336-8

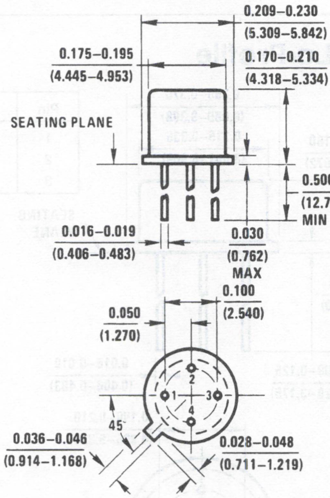
TO-71 (08, 12)


0.209–0.219
(5.309–5.563)
0.178–0.191
(4.521–4.851)
0.188–0.210
(4.775–5.334)
SEATING PLANE
0.030
(0.762)
MAX
0.016–0.019
(0.406–0.483)
0.500
(12.70)
MIN
0.100
(2.540)
0.050
(1.270)
2
3
1
5
7
6
45°
0.036–0.046
(0.914–1.168)
0.028–0.048
(0.711–1.219)

Pin	FET (12)
1	S1
2	D1
3	G1
5	S2
6	D2
7	G2

TL/G/10336-9

TO-72 (23, 25, 28, 29)


0.209–0.230
(5.309–5.842)
0.175–0.195
(4.445–4.953)
0.170–0.210
(4.318–5.334)
SEATING PLANE
0.500
(12.70)
MIN
0.016–0.019
(0.406–0.483)
0.030
(0.762)
MAX
0.100
(2.540)
0.050
(1.270)
2
1
3
4
45°
0.036–0.046
(0.914–1.168)
0.028–0.048
(0.711–1.219)

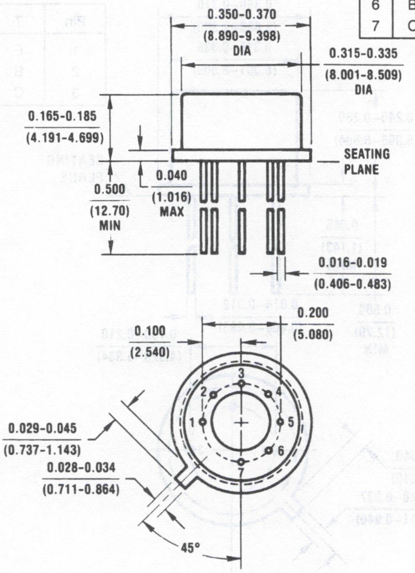
TL/G/10336-10

Pin	T(25)	FET N(25, 29)
1	E	S
2	B	D
3	C	G
4	GND	CASE

Pin	T(28)	FET P(23)
1	B	S
2	E	G
3	C	D
4	GND	CASE

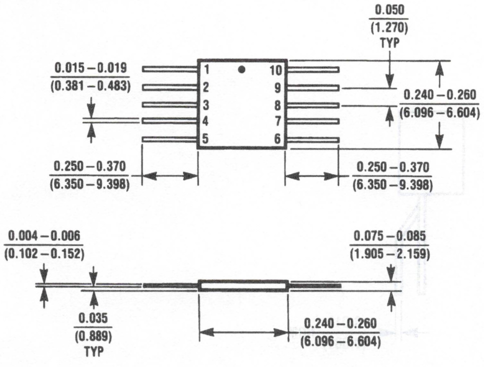
TO-78 (24, 30)

Pin	T(30)	FET(24)
1	E1	S1
2	B1	D1
3	C1	G1
5	E2	S2
6	B2	D2
7	C2	G2


0.350–0.370
(8.890–9.398)
DIA
0.315–0.335
(8.001–8.509)
DIA
0.165–0.185
(4.191–4.699)
SEATING PLANE
0.040
(1.016)
MAX
0.500
(12.70)
MIN
0.016–0.019
(0.406–0.483)
0.200
(5.080)
0.100
(2.540)
3
2
4
1
5
6
7
0.029–0.045
(0.737–1.143)
0.028–0.034
(0.711–0.864)
45°

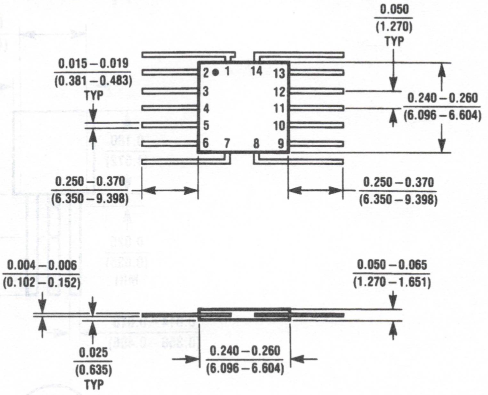
TL/G/10336-11

TO-85 (14)
(Diode Arrays)


0.050
(1.270)
TYP
0.015–0.019
(0.381–0.483)
1
2
3
4
5
10
9
8
7
6
0.240–0.260
(6.096–6.604)
0.250–0.370
(6.350–9.398)
0.250–0.370
(6.350–9.398)
0.004–0.006
(0.102–0.152)
0.075–0.085
(1.905–2.159)
0.035
(0.889)
TYP
0.240–0.260
(6.096–6.604)

TL/G/10336-12

TO-86 (26)
(Diode Arrays)


0.050
(1.270)
TYP
0.015–0.019
(0.381–0.483)
TYP
2
1
14
13
3
12
4
11
5
10
6
7
8
9
0.240–0.260
(6.096–6.604)
0.250–0.370
(6.350–9.398)
0.250–0.370
(6.350–9.398)
0.004–0.006
(0.102–0.152)
0.050–0.065
(1.270–1.651)
0.025
(0.635)
TYP
0.240–0.260
(6.096–6.604)

TL/G/10336-13

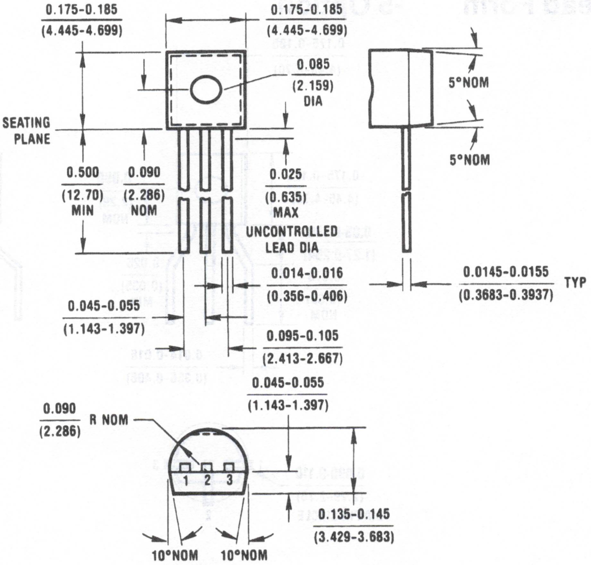
TO-92 (92, 94, 96, 97, 98)

Pin	(92) STD	
	T	FET
1	C	G
2	B	S
3	E	D

Pin	(94)	
	T	FET
1	B	S
2	C	G
3	E	D

Pin	(96)	
	T	FET
1	C	G
2	E	D
3	B	S

Pin	(97)*		(98)*
	T	FET	T
1	E	D	B
2	B	S	E
3	C	G	C

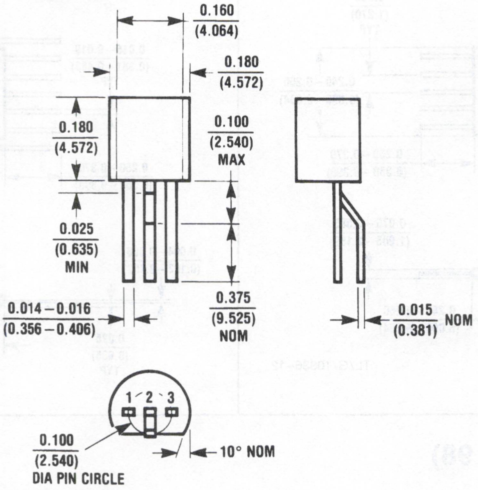

0.175-0.185
(4.445-4.699)
0.175-0.185
(4.445-4.699)
0.085
(2.159)
DIA
5°NOM
5°NOM
SEATING
PLANE
0.500
(12.70)
MIN
0.090
(2.286)
NOM
0.025
(0.635)
MAX
UNCONTROLLED
LEAD DIA
0.014-0.016
(0.356-0.406)
0.0145-0.0155
(0.3683-0.3937)
TYP
0.045-0.055
(1.143-1.397)
0.095-0.105
(2.413-2.667)
0.045-0.055
(1.143-1.397)
0.090
(2.286)
R NOM
1
2
3
0.135-0.145
(3.429-3.683)
10°NOM
10°NOM

TL/G/10336-14

*Leadformed to TO-18 configuration prior to bulk shipment. For in-line leads, order option L342.

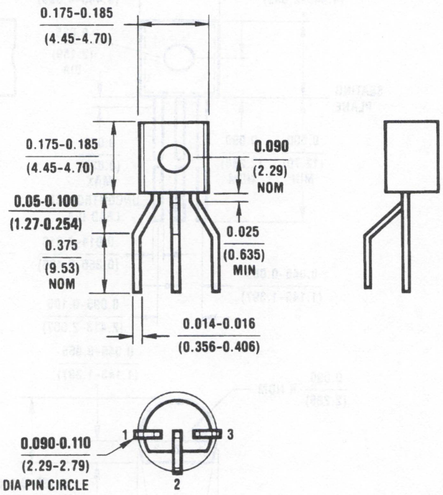
Drain-Source Interchangeable on most JFET Devices.

TO-92 (92, 94, 96) TO-18 Lead Form -18 Option


0.160
(4.064)
0.180
(4.572)
0.180
(4.572)
0.100
(2.540)
MAX
0.025
(0.635)
MIN
0.375
(9.525)
NOM
0.014 – 0.016
(0.356 – 0.406)
0.015
(0.381)
NOM
1
2
3
0.100
(2.540)
DIA PIN CIRCLE
10° NOM

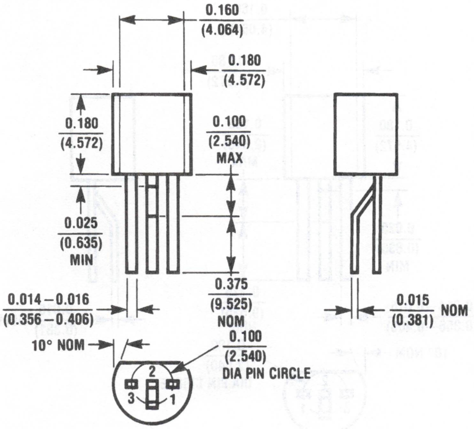
TL/G/10336–15

TO-92 (92, 94 ,96) TO-5 Lead Form -5 Option


0.175-0.185
(4.45-4.70)
0.175-0.185
(4.45-4.70)
0.090
(2.29)
NOM
0.05-0.100
(1.27-0.254)
0.025
(0.635)
MIN
0.375
(9.53)
NOM
0.014-0.016
(0.356-0.406)
1
3
2
0.090-0.110
(2.29-2.79)
DIA PIN CIRCLE

TL/G/10336–16

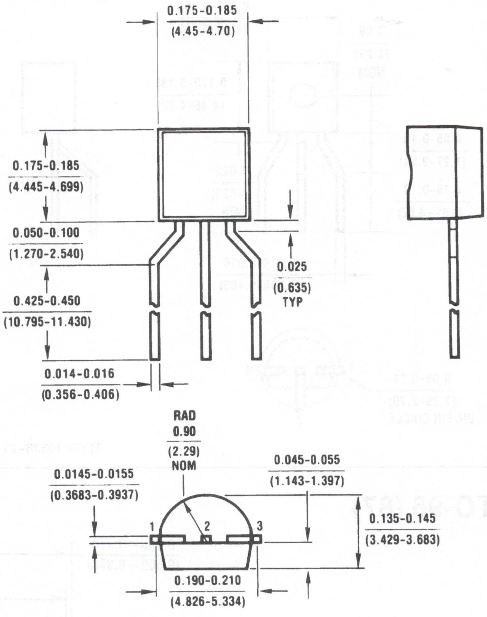
TO-92 (97, 98) TO-18 Lead Form STD*


0.160
(4.064)
0.180
(4.572)
0.180
(4.572)
0.100
(2.540)
MAX
0.025
(0.635)
MIN
0.375
(9.525)
NOM
0.014–0.016
(0.356–0.406)
0.015
(0.381)
NOM
10° NOM
0.100
(2.540)
DIA PIN CIRCLE
1
2
3

TL/G/10336-17

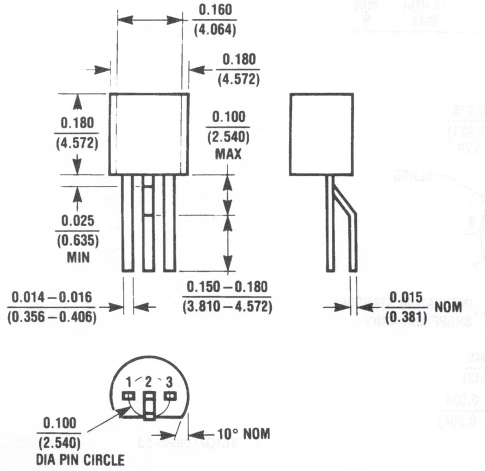
*__Note:__ All package 97 or 98 transistors are leadformed to this configuration prior to bulk shipment. Order L34Z option if in-line leads preferred on these package codes.

TO-92 (92, 94, 96) 0.100″ Spacing Lead Form J61Z Option


0.175-0.185
(4.45-4.70)
0.175-0.185
(4.445-4.699)
0.050-0.100
(1.270-2.540)
0.025
(0.635)
TYP
0.425-0.450
(10.795-11.430)
0.014-0.016
(0.356-0.406)
RAD
0.90
(2.29)
NOM
0.0145-0.0155
(0.3683-0.3937)
0.045-0.055
(1.143-1.397)
1
2
3
0.135-0.145
(3.429-3.683)
0.190-0.210
(4.826-5.334)

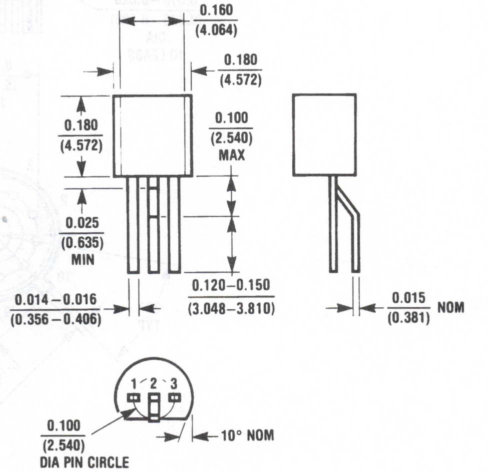
TL/G/10336-18

TO-92 (92, 94, 96) TO-18 Lead Form and Crop J14Z Option


0.160
(4.064)
0.180
(4.572)
0.180
(4.572)
0.100
(2.540)
MAX
0.025
(0.635)
MIN
0.014–0.016
(0.356–0.406)
0.150–0.180
(3.810–4.572)
0.015
(0.381)
NOM
1
2
3
0.100
(2.540)
DIA PIN CIRCLE
10° NOM

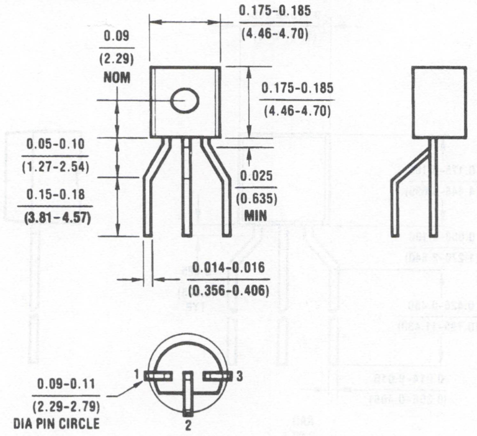
TL/G/10336-19

TO-92 (92, 94, 96) TO-18 Lead Form and Crop J22Z Option


0.160
(4.064)
0.180
(4.572)
0.180
(4.572)
0.100
(2.540)
MAX
0.025
(0.635)
MIN
0.120–0.150
(3.048–3.810)
0.014–0.016
(0.356–0.406)
0.015
(0.381)
NOM
1
2
3
0.100
(2.540)
DIA PIN CIRCLE
10° NOM

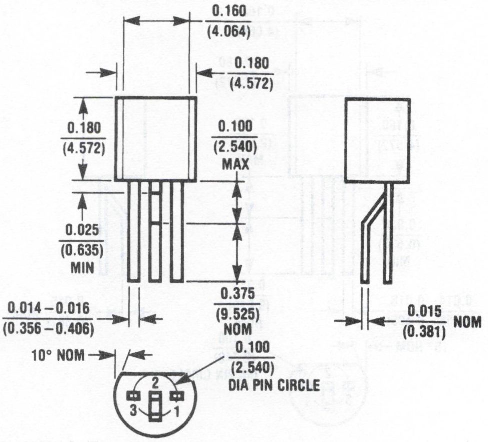
TL/G/10336-20

TO-92 (92, 94, 96) TO-5 Lead Form and Crop J25Z Option


0.175-0.185
(4.46-4.70)
0.09
(2.29)
NOM
0.175-0.185
(4.46-4.70)
0.05-0.10
(1.27-2.54)
0.15-0.18
(3.81-4.57)
0.025
(0.635)
MIN
0.014-0.016
(0.356-0.406)
0.09-0.11
(2.29-2.79)
DIA PIN CIRCLE
1
2
3

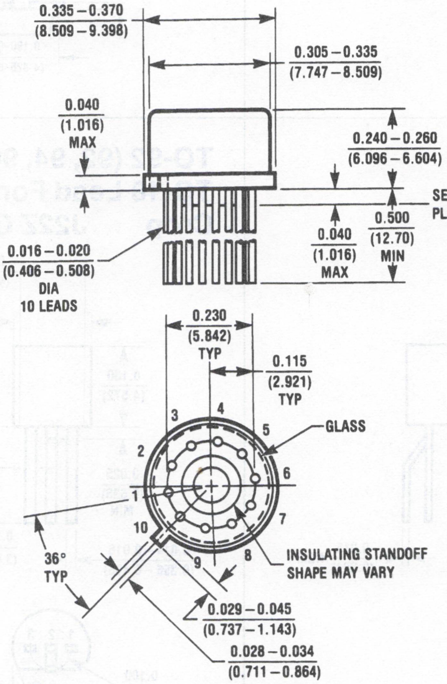
TL/G/10336-21

TO-92 (94) TO-18 Lead Form J35Z Option


0.160
(4.064)
0.180
(4.572)
0.180
(4.572)
0.100
(2.540)
MAX
0.025
(0.635)
MIN
0.375
(9.525)
NOM
0.014-0.016
(0.356-0.406)
0.015
(0.381)
NOM
10° NOM
0.100
(2.540)
DIA PIN CIRCLE
1
2
3

TL/G/10336-22

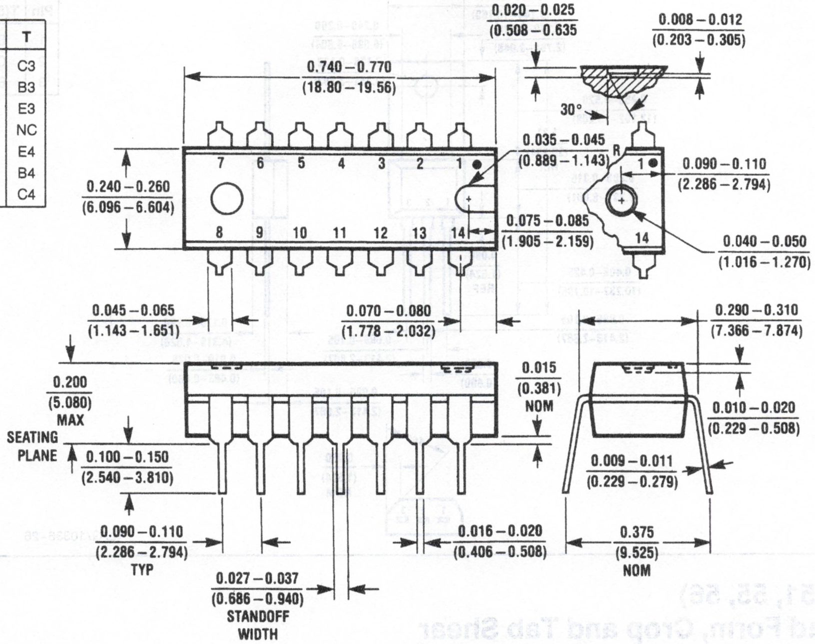
TO-96 (87)


0.335-0.370
(8.509-9.398)
0.305-0.335
(7.747-8.509)
0.040
(1.016)
MAX
0.240-0.260
(6.096-6.604)
SEATING PLANE
0.500
(12.70)
MIN
0.040
(1.016)
MAX
0.016-0.020
(0.406-0.508)
DIA
10 LEADS
0.230
(5.842)
TYP
0.115
(2.921)
TYP
GLASS
INSULATING STANDOFF SHAPE MAY VARY
36°
TYP
0.029-0.045
(0.737-1.143)
0.028-0.034
(0.711-0.864)
1
2
3
4
5
6
7
8
9
10

TL/G/10336-23

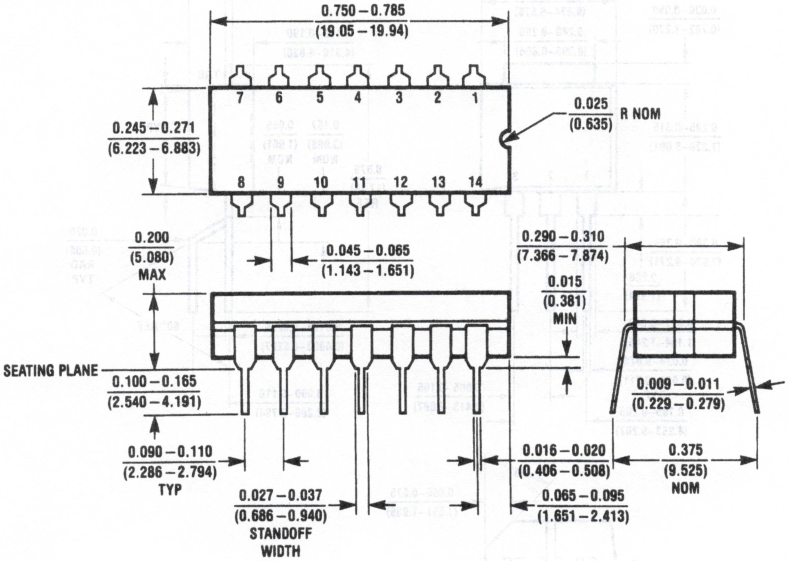
TO-116 (01)

Pin	T	Pin	T
1	C1	8	C3
2	B1	9	B3
3	E1	10	E3
4	NC	11	NC
5	E2	12	E4
6	B2	13	B4
7	C2	14	C4


0.020 – 0.025
(0.508 – 0.635)
0.008 – 0.012
(0.203 – 0.305)
0.740 – 0.770
(18.80 – 19.56)
30°
0.035 – 0.045
(0.889 – 1.143)
R
0.090 – 0.110
(2.286 – 2.794)
7 6 5 4 3 2 1
1
0.240 – 0.260
(6.096 – 6.604)
8 9 10 11 12 13 14
14
0.075 – 0.085
(1.905 – 2.159)
0.040 – 0.050
(1.016 – 1.270)
0.045 – 0.065
(1.143 – 1.651)
0.070 – 0.080
(1.778 – 2.032)
0.290 – 0.310
(7.366 – 7.874)
0.200
(5.080)
MAX
0.015
(0.381)
NOM
0.010 – 0.020
(0.229 – 0.508)
SEATING PLANE
0.100 – 0.150
(2.540 – 3.810)
0.009 – 0.011
(0.229 – 0.279)
0.090 – 0.110
(2.286 – 2.794)
TYP
0.016 – 0.020
(0.406 – 0.508)
0.375
(9.525)
NOM
0.027 – 0.037
(0.686 – 0.940)
STANDOFF
WIDTH

TL/G/10336-24

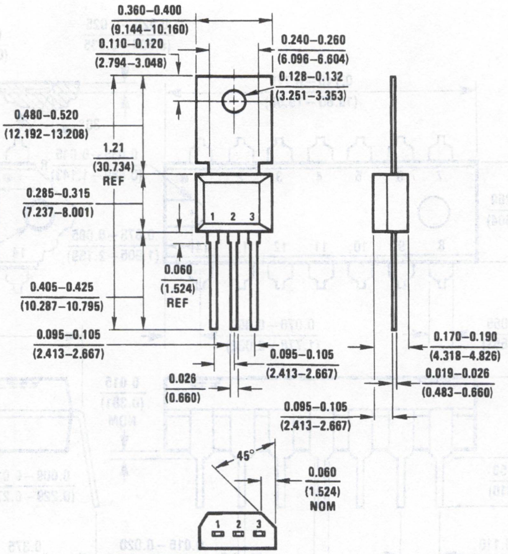
TO-116-2 (35)
(Diode Arrays)


0.750 – 0.785
(19.05 – 19.94)
7 6 5 4 3 2 1
0.025
(0.635)
R NOM
0.245 – 0.271
(6.223 – 6.883)
8 9 10 11 12 13 14
0.200
(5.080)
MAX
0.045 – 0.065
(1.143 – 1.651)
0.290 – 0.310
(7.366 – 7.874)
0.015
(0.381)
MIN
SEATING PLANE
0.100 – 0.165
(2.540 – 4.191)
0.009 – 0.011
(0.229 – 0.279)
0.090 – 0.110
(2.286 – 2.794)
TYP
0.016 – 0.020
(0.406 – 0.508)
0.375
(9.525)
NOM
0.027 – 0.037
(0.686 – 0.940)
STANDOFF
WIDTH
0.065 – 0.095
(1.651 – 2.413)

TL/G/10336-25

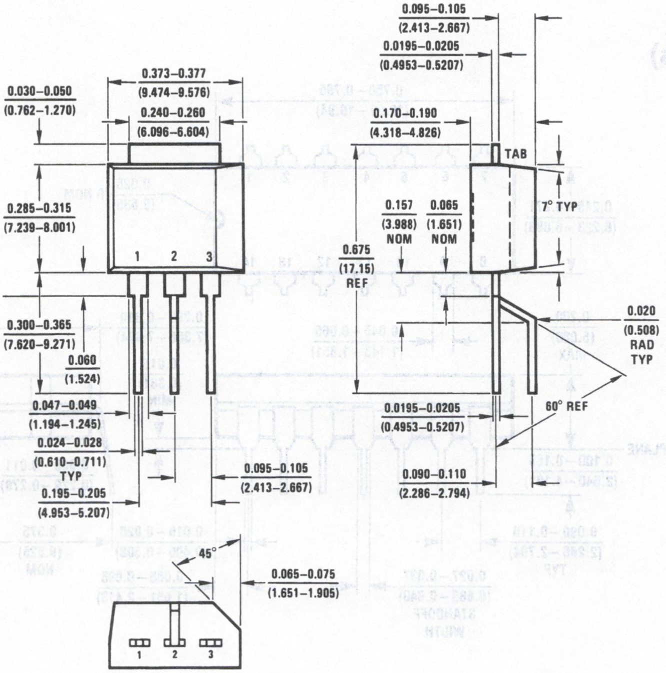
TO-202 (51, 55, 56)

Pin	T(51)	T(55)	T(56)
1	E	E	B
2	C	B	C
3	B	C	E


0.360–0.400
(9.144–10.160)
0.110–0.120
(2.794–3.048)
0.240–0.260
(6.096–6.604)
0.128–0.132
(3.251–3.353)
0.480–0.520
(12.192–13.208)
1.21
(30.734)
REF
0.285–0.315
(7.237–8.001)
1 2 3
0.060
(1.524)
REF
0.405–0.425
(10.287–10.795)
0.095–0.105
(2.413–2.667)
0.170–0.190
(4.318–4.826)
0.095–0.105
(2.413–2.667)
0.019–0.026
(0.483–0.660)
0.026
(0.660)
0.095–0.105
(2.413–2.667)
45°
0.060
(1.524)
NOM
1 2 3

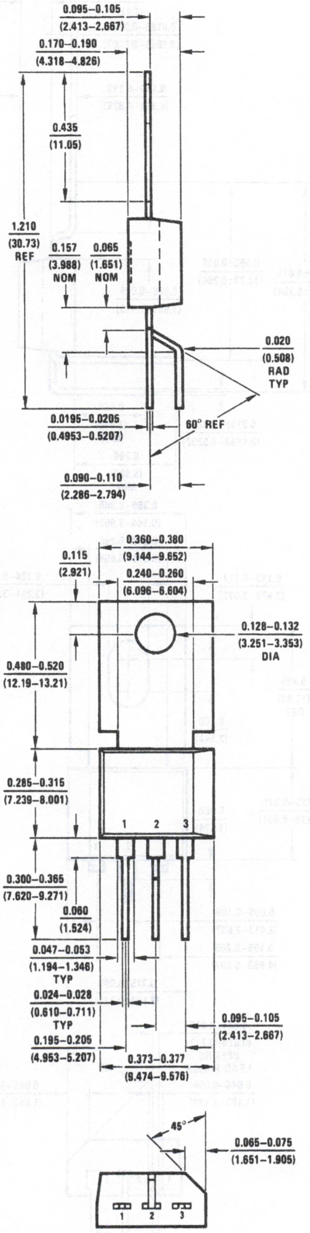
TL/G/10336-26

TO-202 (51, 55, 56)
TO-5 Lead Form, Crop and Tab Shear
J46Z Option


0.095–0.105
(2.413–2.667)
0.0195–0.0205
(0.4953–0.5207)
0.373–0.377
(9.474–9.576)
0.030–0.050
(0.762–1.270)
0.240–0.260
(6.096–6.604)
0.170–0.190
(4.318–4.826)
TAB
0.285–0.315
(7.239–8.001)
0.157
(3.988)
NOM
0.065
(1.651)
NOM
7° TYP
0.675
(17.15)
REF
1 2 3
0.300–0.365
(7.620–9.271)
0.020
(0.508)
RAD
TYP
0.060
(1.524)
0.047–0.049
(1.194–1.245)
0.0195–0.0205
(0.4953–0.5207)
60° REF
0.024–0.028
(0.610–0.711)
TYP
0.195–0.205
(4.953–5.207)
0.095–0.105
(2.413–2.667)
0.090–0.110
(2.286–2.794)
45°
0.065–0.075
(1.651–1.905)
1 2 3

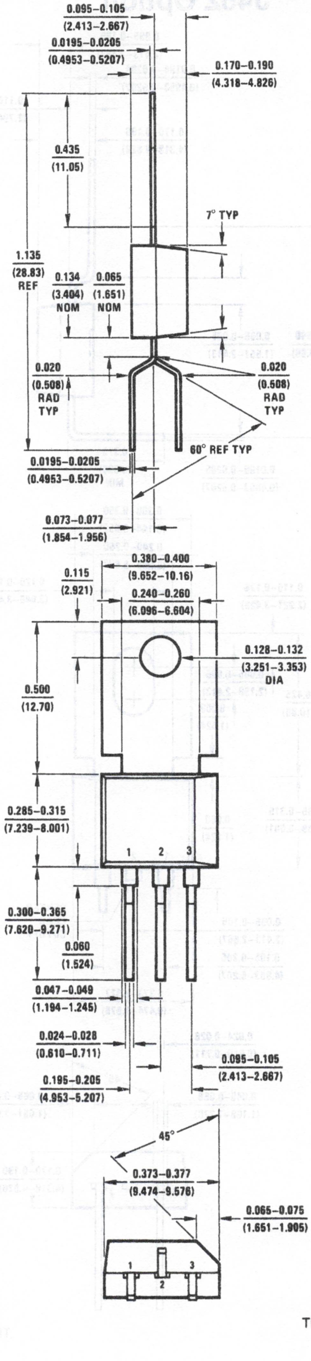
TL/G/10336-27

TO-202 (51, 55, 56) TO-5 Lead Form and Crop J41Z Option


0.095–0.105
(2.413–2.667)
0.170–0.190
(4.318–4.826)
0.435
(11.05)
1.210
(30.73)
REF
0.157
(3.988)
NOM
0.065
(1.651)
NOM
0.020
(0.508)
RAD
TYP
0.0195–0.0205
(0.4953–0.5207)
60° REF
0.090–0.110
(2.286–2.794)
0.360–0.380
(9.144–9.652)
0.115
(2.921)
0.240–0.260
(6.096–6.604)
0.128–0.132
(3.251–3.353)
DIA
0.480–0.520
(12.19–13.21)
0.285–0.315
(7.239–8.001)
1
2
3
0.300–0.365
(7.620–9.271)
0.060
(1.524)
0.047–0.053
(1.194–1.346)
TYP
0.024–0.028
(0.610–0.711)
TYP
0.195–0.205
(4.953–5.207)
0.373–0.377
(9.474–9.576)
0.095–0.105
(2.413–2.667)
45°
0.065–0.075
(1.651–1.905)
1
2
3

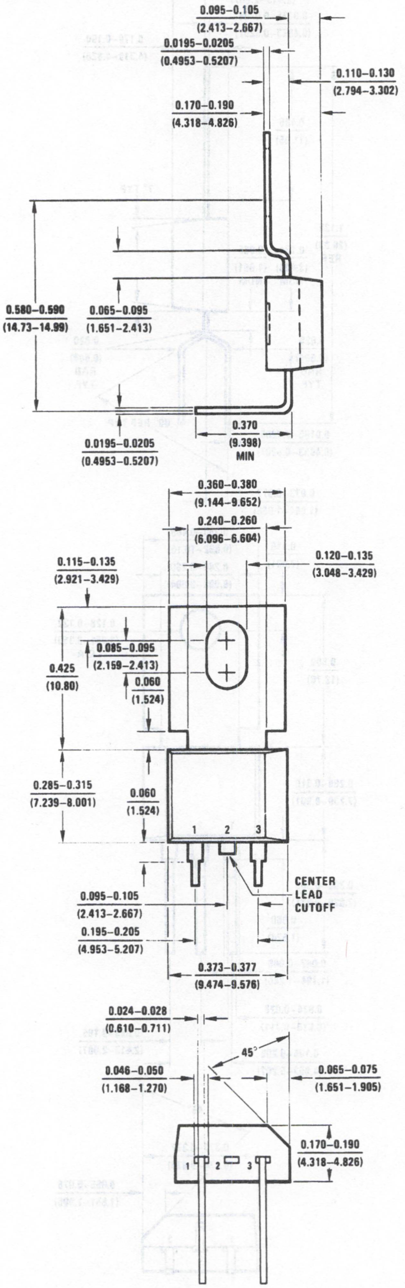
TL/G/10336-28

TO-202 (51, 55, 56) Lead Form J52Z Option


0.095–0.105
(2.413–2.667)
0.0195–0.0205
(0.4953–0.5207)
0.170–0.190
(4.318–4.826)
0.435
(11.05)
7° TYP
1.135
(28.83)
REF
0.134
(3.404)
NOM
0.065
(1.651)
NOM
0.020
(0.508)
RAD
TYP
0.020
(0.508)
RAD
TYP
60° REF TYP
0.0195–0.0205
(0.4953–0.5207)
0.073–0.077
(1.854–1.956)
0.380–0.400
(9.652–10.16)
0.115
(2.921)
0.240–0.260
(6.096–6.604)
0.128–0.132
(3.251–3.353)
DIA
0.500
(12.70)
0.285–0.315
(7.239–8.001)
1
2
3
0.300–0.365
(7.620–9.271)
0.060
(1.524)
0.047–0.049
(1.194–1.245)
0.024–0.028
(0.610–0.711)
0.095–0.105
(2.413–2.667)
0.195–0.205
(4.953–5.207)
45°
0.373–0.377
(9.474–9.576)
0.065–0.075
(1.651–1.905)
1
3
2

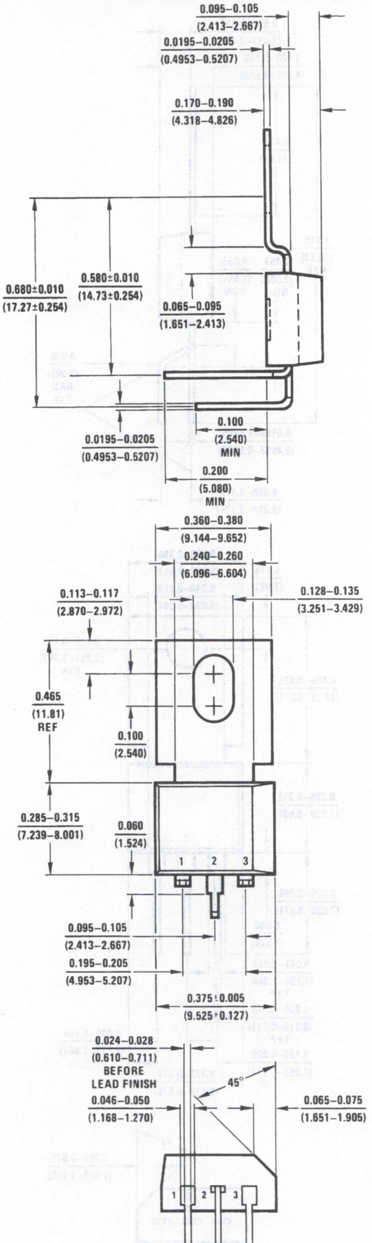
TL/G/10336-29

TO-202 (51, 55, 56) TO-66 Lead Form, Crop and Tab Form J45Z Option


0.095–0.105
(2.413–2.667)
0.0195–0.0205
(0.4953–0.5207)
0.110–0.130
(2.794–3.302)
0.170–0.190
(4.318–4.826)
0.580–0.590
(14.73–14.99)
0.065–0.095
(1.651–2.413)
0.0195–0.0205
(0.4953–0.5207)
0.370
(9.398)
MIN
0.360–0.380
(9.144–9.652)
0.240–0.260
(6.096–6.604)
0.115–0.135
(2.921–3.429)
0.120–0.135
(3.048–3.429)
0.085–0.095
(2.159–2.413)
0.425
(10.80)
0.060
(1.524)
0.285–0.315
(7.239–8.001)
0.060
(1.524)
1
2
3
CENTER
LEAD
CUTOFF
0.095–0.105
(2.413–2.667)
0.195–0.205
(4.953–5.207)
0.373–0.377
(9.474–9.576)
0.024–0.028
(0.610–0.711)
45°
0.046–0.050
(1.168–1.270)
0.065–0.075
(1.651–1.905)
0.170–0.190
(4.318–4.826)
1
2
3

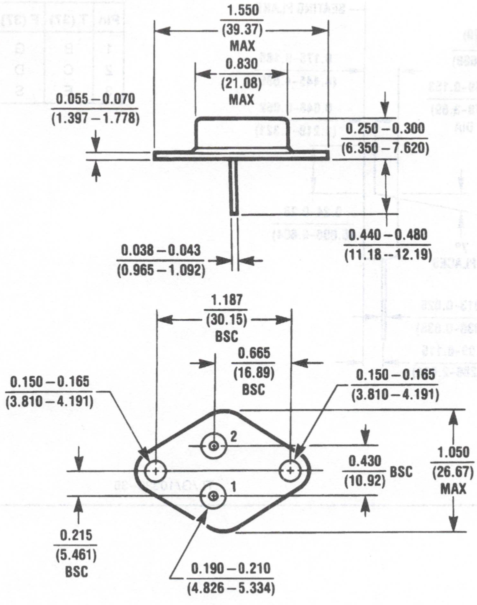
TL/G/10336-30

TO-202 (51, 55, 56) TO-5 Lead Form for Flush Mount J68Z Option


0.095–0.105
(2.413–2.667)
0.0195–0.0205
(0.4953–0.5207)
0.170–0.190
(4.318–4.826)
0.680±0.010
(17.27±0.254)
0.580±0.010
(14.73±0.254)
0.065–0.095
(1.651–2.413)
0.0195–0.0205
(0.4953–0.5207)
0.100
(2.540)
MIN
0.200
(5.080)
MIN
0.360–0.380
(9.144–9.652)
0.240–0.260
(6.096–6.604)
0.113–0.117
(2.870–2.972)
0.128–0.135
(3.251–3.429)
0.465
(11.81)
REF
0.100
(2.540)
0.285–0.315
(7.239–8.001)
0.060
(1.524)
1
2
3
0.095–0.105
(2.413–2.667)
0.195–0.205
(4.953–5.207)
0.375±0.005
(9.525±0.127)
0.024–0.028
(0.610–0.711)
BEFORE
LEAD FINISH
45°
0.046–0.050
(1.168–1.270)
0.065–0.075
(1.651–1.905)
1
2
3

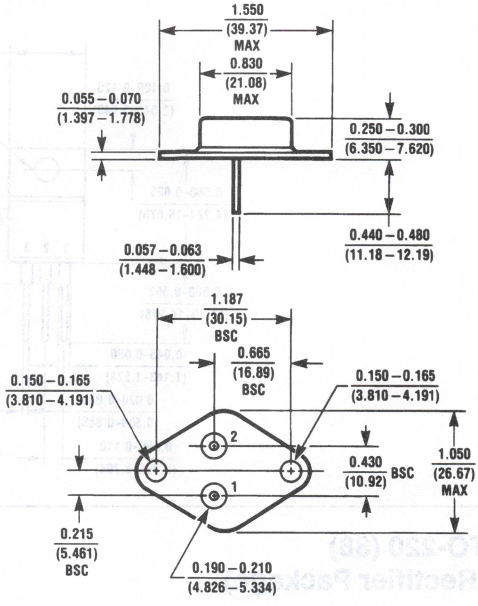
TL/G/10336-31

TO-204AA (42)


1.550
(39.37)
MAX
0.830
(21.08)
MAX
0.055 – 0.070
(1.397 – 1.778)
0.250 – 0.300
(6.350 – 7.620)
0.440 – 0.480
(11.18 – 12.19)
0.038 – 0.043
(0.965 – 1.092)
1.187
(30.15)
BSC
0.665
(16.89)
BSC
0.150 – 0.165
(3.810 – 4.191)
0.150 – 0.165
(3.810 – 4.191)
2
1
0.430
(10.92)
BSC
1.050
(26.67)
MAX
0.215
(5.461)
BSC
0.190 – 0.210
(4.826 – 5.334)

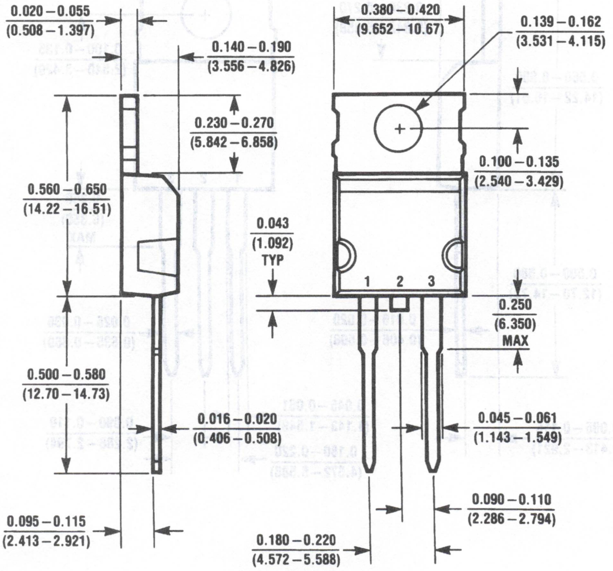
TL/G/10336-32

TO-204AE (43)


1.550
(39.37)
MAX
0.830
(21.08)
MAX
0.055 – 0.070
(1.397 – 1.778)
0.250 – 0.300
(6.350 – 7.620)
0.440 – 0.480
(11.18 – 12.19)
0.057 – 0.063
(1.448 – 1.600)
1.187
(30.15)
BSC
0.665
(16.89)
BSC
0.150 – 0.165
(3.810 – 4.191)
0.150 – 0.165
(3.810 – 4.191)
2
1
0.430
(10.92)
BSC
1.050
(26.67)
MAX
0.215
(5.461)
BSC
0.190 – 0.210
(4.826 – 5.334)

TL/G/10336-33

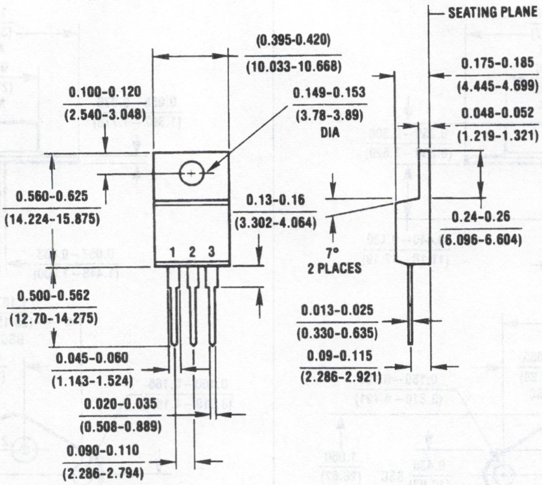
TO-220 (41)
(Rectifier Package)


0.020 – 0.055
(0.508 – 1.397)
0.140 – 0.190
(3.556 – 4.826)
0.230 – 0.270
(5.842 – 6.858)
0.560 – 0.650
(14.22 – 16.51)
0.500 – 0.580
(12.70 – 14.73)
0.016 – 0.020
(0.406 – 0.508)
0.095 – 0.115
(2.413 – 2.921)
0.380 – 0.420
(9.652 – 10.67)
0.139 – 0.162
(3.531 – 4.115)
0.100 – 0.135
(2.540 – 3.429)
0.043
(1.092)
TYP
1
2
3
0.250
(6.350)
MAX
0.045 – 0.061
(1.143 – 1.549)
0.090 – 0.110
(2.286 – 2.794)
0.180 – 0.220
(4.572 – 5.588)

Pin	R(41)
1	A
2	CUT
3	C

TL/G/10336-34

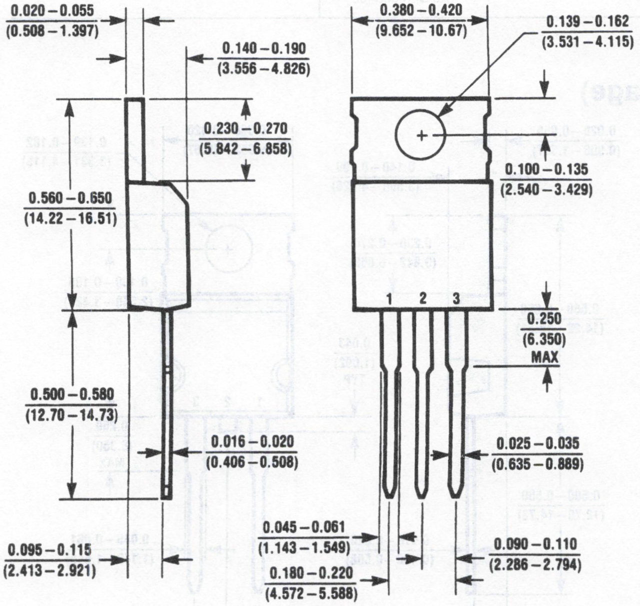
TO-220 (37)


SEATING PLANE
(0.395-0.420)
(10.033-10.668)
0.175-0.185
(4.445-4.699)
0.100-0.120
(2.540-3.048)
0.149-0.153
(3.78-3.89)
DIA
0.048-0.052
(1.219-1.321)
0.560-0.625
(14.224-15.875)
0.13-0.16
(3.302-4.064)
0.24-0.26
(6.096-6.604)
7°
2 PLACES
1 2 3
0.500-0.562
(12.70-14.275)
0.013-0.025
(0.330-0.635)
0.09-0.115
(2.286-2.921)
0.045-0.060
(1.143-1.524)
0.020-0.035
(0.508-0.889)
0.090-0.110
(2.286-2.794)

Pin	T (37)	F (37)
1	B	G
2	C	D
3	E	S

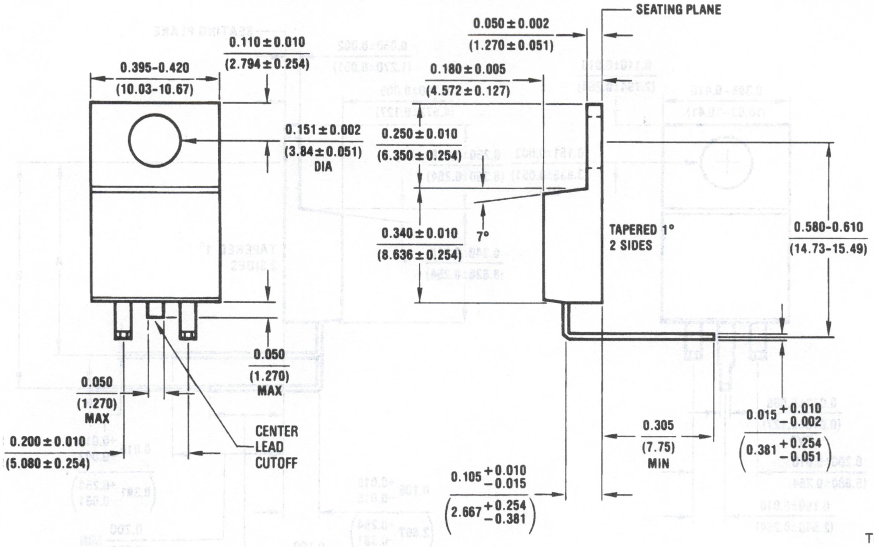
TL/G/10336-35

TO-220 (38) (Rectifier Package)


0.020 – 0.055
(0.508 – 1.397)
0.380 – 0.420
(9.652 – 10.67)
0.139 – 0.162
(3.531 – 4.115)
0.140 – 0.190
(3.556 – 4.826)
0.230 – 0.270
(5.842 – 6.858)
0.100 – 0.135
(2.540 – 3.429)
0.560 – 0.650
(14.22 – 16.51)
1 2 3
0.250
(6.350)
MAX
0.500 – 0.580
(12.70 – 14.73)
0.016 – 0.020
(0.406 – 0.508)
0.025 – 0.035
(0.635 – 0.889)
0.045 – 0.061
(1.143 – 1.549)
0.095 – 0.115
(2.413 – 2.921)
0.090 – 0.110
(2.286 – 2.794)
0.180 – 0.220
(4.572 – 5.588)

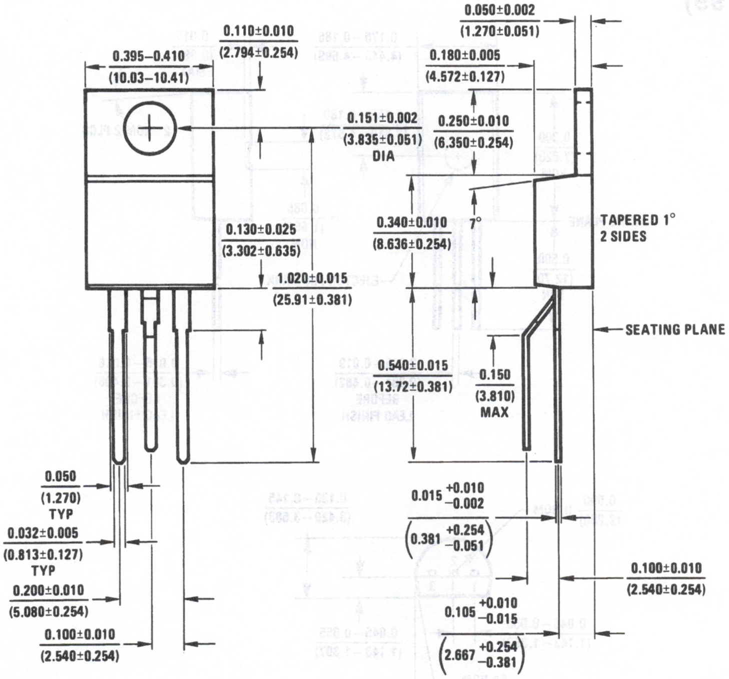
TL/G/10336-36

TO-220 (37, 41)
TO-66 Lead Form and Crop J48Z Option


SEATING PLANE
0.050 ± 0.002
(1.270 ± 0.051)
0.110 ± 0.010
(2.794 ± 0.254)
0.395-0.420
(10.03-10.67)
0.180 ± 0.005
(4.572 ± 0.127)
0.151 ± 0.002
(3.84 ± 0.051)
DIA
0.250 ± 0.010
(6.350 ± 0.254)
0.340 ± 0.010
(8.636 ± 0.254)
7°
TAPERED 1°
2 SIDES
0.580-0.610
(14.73-15.49)
0.050
(1.270)
MAX
0.050
(1.270)
MAX
0.200 ± 0.010
(5.080 ± 0.254)
CENTER
LEAD
CUTOFF
0.305
(7.75)
MIN
0.015 +0.010 −0.002
(0.381 +0.254 −0.051)
0.105 +0.010 −0.015
(2.667 +0.254 −0.381)

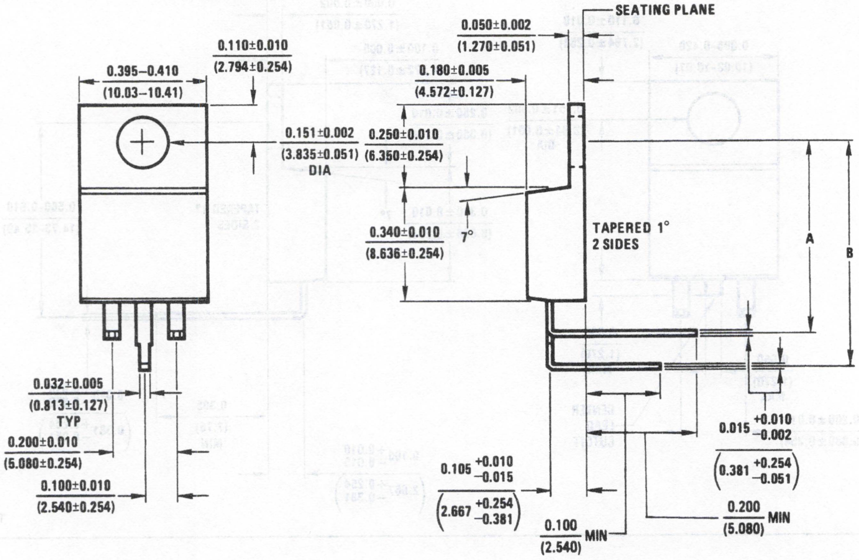
TL/G/10336-37

TO-220 (37, 38)
TO-5 Lead Form J69Z Option


0.050±0.002
(1.270±0.051)
0.110±0.010
(2.794±0.254)
0.395–0.410
(10.03–10.41)
0.180±0.005
(4.572±0.127)
0.151±0.002
(3.835±0.051)
DIA
0.250±0.010
(6.350±0.254)
0.340±0.010
(8.636±0.254)
7°
TAPERED 1°
2 SIDES
0.130±0.025
(3.302±0.635)
1.020±0.015
(25.91±0.381)
SEATING PLANE
0.540±0.015
(13.72±0.381)
0.150
(3.810)
MAX
0.050
(1.270)
TYP
0.032±0.005
(0.813±0.127)
TYP
0.200±0.010
(5.080±0.254)
0.100±0.010
(2.540±0.254)
0.015 +0.010 −0.002
(0.381 +0.254 −0.051)
0.100±0.010
(2.540±0.254)
0.105 +0.010 −0.015
(2.667 +0.254 −0.381)

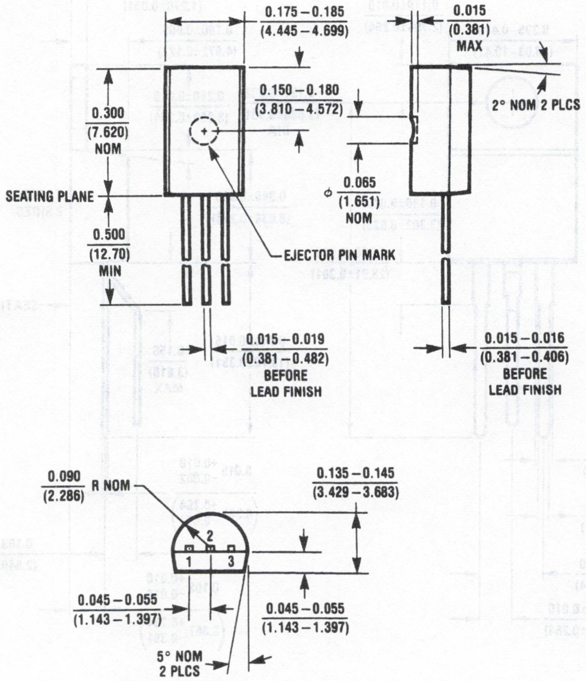
TL/G/10336-38

TO-220 (37, 38)
TO-5 Lead Form for Flush Mount J67Z Option


SEATING PLANE
0.050±0.002
(1.270±0.051)
0.110±0.010
(2.794±0.254)
0.395–0.410
(10.03–10.41)
0.180±0.005
(4.572±0.127)
0.151±0.002
(3.835±0.051)
DIA
0.250±0.010
(6.350±0.254)
7°
0.340±0.010
(8.636±0.254)
TAPERED 1°
2 SIDES
A
B
0.032±0.005
(0.813±0.127)
TYP
0.200±0.010
(5.080±0.254)
0.100±0.010
(2.540±0.254)
0.015 +0.010 −0.002
(0.381 +0.254 −0.051)
0.105 +0.010 −0.015
(2.667 +0.254 −0.381)
0.200
(5.080)
MIN
0.100
(2.540)
MIN

TL/G/10336-39

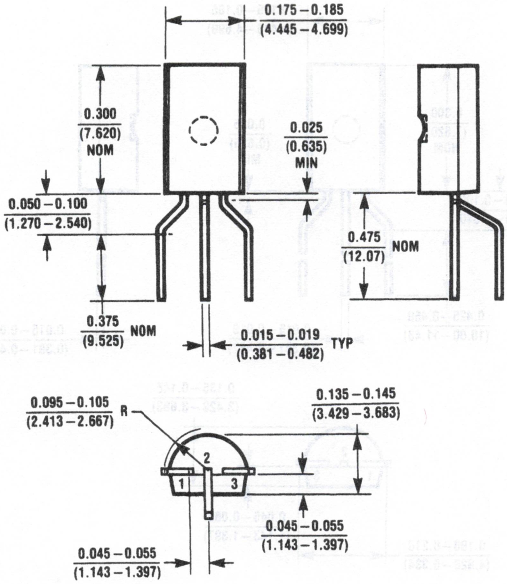
TO-226 (95, 99)


0.175 – 0.185
(4.445 – 4.699)
0.015
(0.381)
MAX
0.300
(7.620)
NOM
0.150 – 0.180
(3.810 – 4.572)
2° NOM 2 PLCS
SEATING PLANE
ϕ 0.065
(1.651)
NOM
0.500
(12.70)
MIN
EJECTOR PIN MARK
0.015 – 0.019
(0.381 – 0.482)
BEFORE
LEAD FINISH
0.015 – 0.016
(0.381 – 0.406)
BEFORE
LEAD FINISH
0.090
(2.286)
R NOM
0.135 – 0.145
(3.429 – 3.683)
1
2
3
0.045 – 0.055
(1.143 – 1.397)
0.045 – 0.055
(1.143 – 1.397)
5° NOM
2 PLCS

Pin	T(95)	T(99)
1	B	C
2	C	B
3	E	E

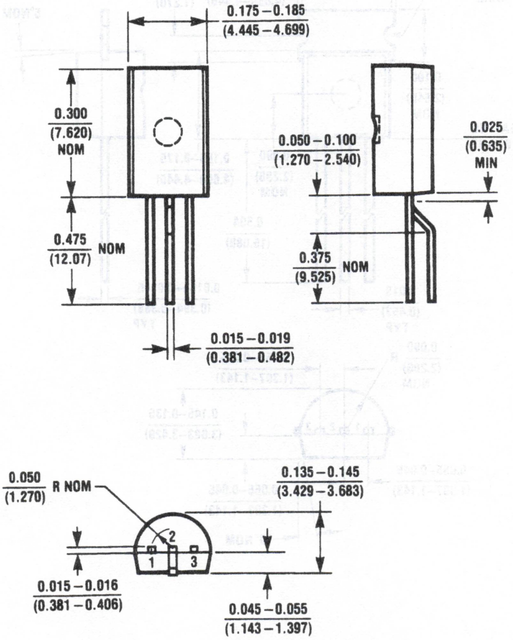
TL/G/10336-40

TO-226 (95, 99)
TO-5 Lead Form
-5 Option


0.175 – 0.185
(4.445 – 4.699)
0.300
(7.620)
NOM
0.025
(0.635)
MIN
0.050 – 0.100
(1.270 – 2.540)
0.475
(12.07)
NOM
0.375
(9.525)
NOM
0.015 – 0.019
(0.381 – 0.482)
TYP
0.095 – 0.105
(2.413 – 2.667)
R
0.135 – 0.145
(3.429 – 3.683)
2
1
3
0.045 – 0.055
(1.143 – 1.397)
0.045 – 0.055
(1.143 – 1.397)

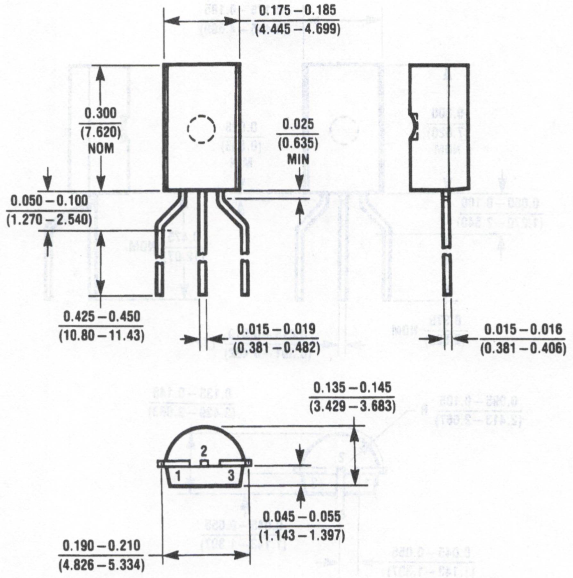
TL/G/10336-41

TO-226 (95, 99)
TO-18 Lead Form
-18 Option


0.175 – 0.185
(4.445 – 4.699)
0.300
(7.620)
NOM
0.050 – 0.100
(1.270 – 2.540)
0.025
(0.635)
MIN
0.475
(12.07)
NOM
0.375
(9.525)
NOM
0.015 – 0.019
(0.381 – 0.482)
0.050
(1.270)
R NOM
0.135 – 0.145
(3.429 – 3.683)
2
1
3
0.015 – 0.016
(0.381 – 0.406)
0.045 – 0.055
(1.143 – 1.397)

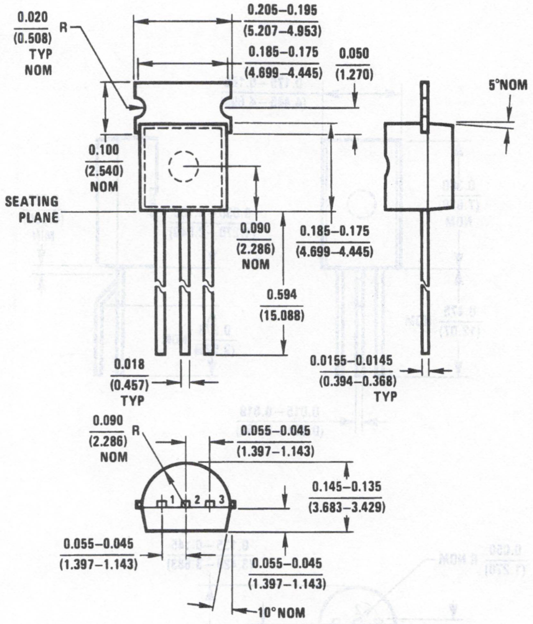
TL/G/10336-42

TO-226 (95, 99)
0.100″ Spacing Lead Form
J61Z Option


0.175 – 0.185
(4.445 – 4.699)
0.300
(7.620)
NOM
0.025
(0.635)
MIN
0.050 – 0.100
(1.270 – 2.540)
0.425 – 0.450
(10.80 – 11.43)
0.015 – 0.019
(0.381 – 0.482)
0.015 – 0.016
(0.381 – 0.406)
0.135 – 0.145
(3.429 – 3.683)
2
1
3
0.045 – 0.055
(1.143 – 1.397)
0.190 – 0.210
(4.826 – 5.334)

TL/G/10336-43

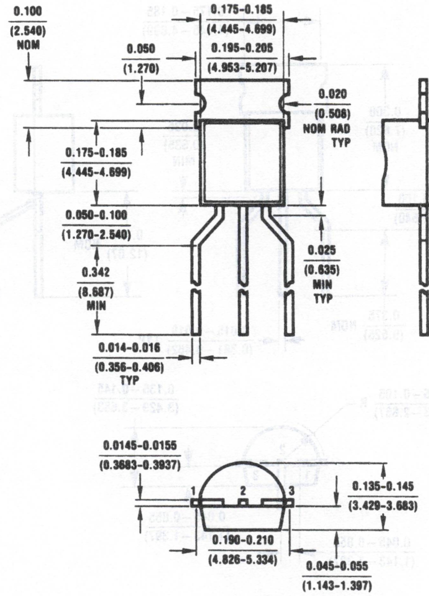
TO-237 (90, 91)


0.020
(0.508)
TYP
NOM
R
0.205–0.195
(5.207–4.953)
0.185–0.175
(4.699–4.445)
0.050
(1.270)
5°NOM
0.100
(2.540)
NOM
SEATING
PLANE
0.090
(2.286)
NOM
0.185–0.175
(4.699–4.445)
0.594
(15.088)
0.018
(0.457)
TYP
0.0155–0.0145
(0.394–0.368)
TYP
0.090
(2.286)
NOM
R
0.055–0.045
(1.397–1.143)
1
2
3
0.145–0.135
(3.683–3.429)
0.055–0.045
(1.397–1.143)
0.055–0.045
(1.397–1.143)
10°NOM

Pin	T(90)	T(91)
1	B	C
2	C	B
3	E	E

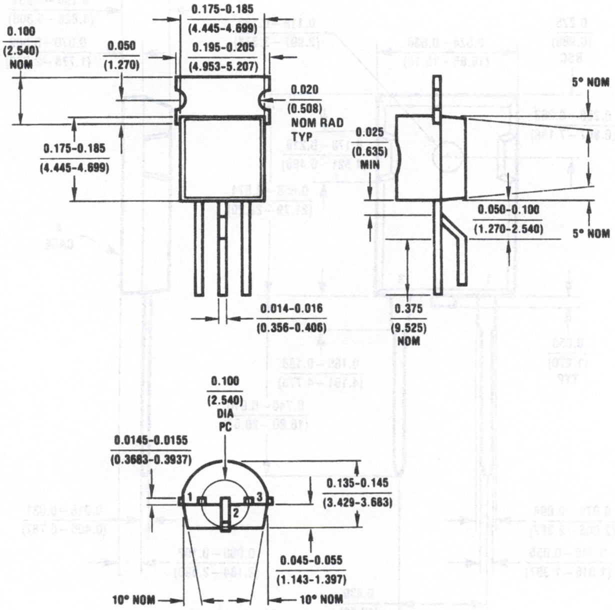
TL/G/10336-44

TO-237 (90, 91)
0.100″ Spacing Lead Form J61Z Option


0.100
(2.540)
NOM
0.175-0.185
(4.445-4.699)
0.050
(1.270)
0.195-0.205
(4.953-5.207)
0.020
(0.508)
NOM RAD
TYP
0.175-0.185
(4.445-4.699)
0.050-0.100
(1.270-2.540)
0.025
(0.635)
MIN
TYP
0.342
(8.687)
MIN
0.014-0.016
(0.356-0.406)
TYP
0.0145-0.0155
(0.3683-0.3937)
1
2
3
0.135-0.145
(3.429-3.683)
0.190-0.210
(4.826-5.334)
0.045-0.055
(1.143-1.397)

TL/G/10336-45

TO-237 (90, 91)
TO-18 Lead Form - 18 Option


0.175-0.185
(4.445-4.699)
0.100
(2.540)
NOM
0.050
(1.270)
0.195-0.205
(4.953-5.207)
0.020
(0.508)
NOM RAD
TYP
0.025
(0.635)
MIN
0.175-0.185
(4.445-4.699)
5° NOM
0.050-0.100
(1.270-2.540)
5° NOM
0.014-0.016
(0.356-0.406)
0.375
(9.525)
NOM
0.100
(2.540)
DIA
PC
0.0145-0.0155
(0.3683-0.3937)
1
3
2
0.135-0.145
(3.429-3.683)
0.045-0.055
(1.143-1.397)
10° NOM
10° NOM

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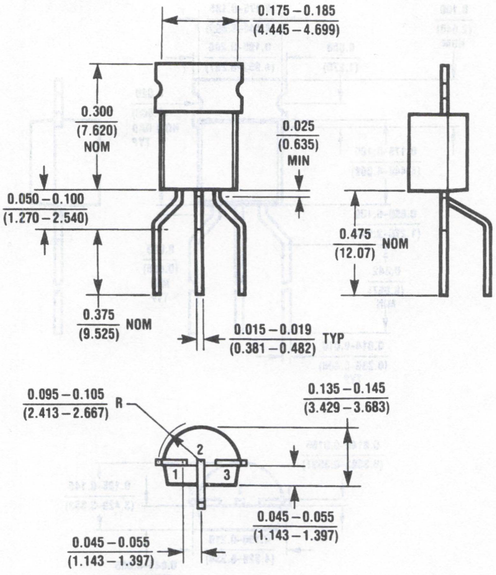
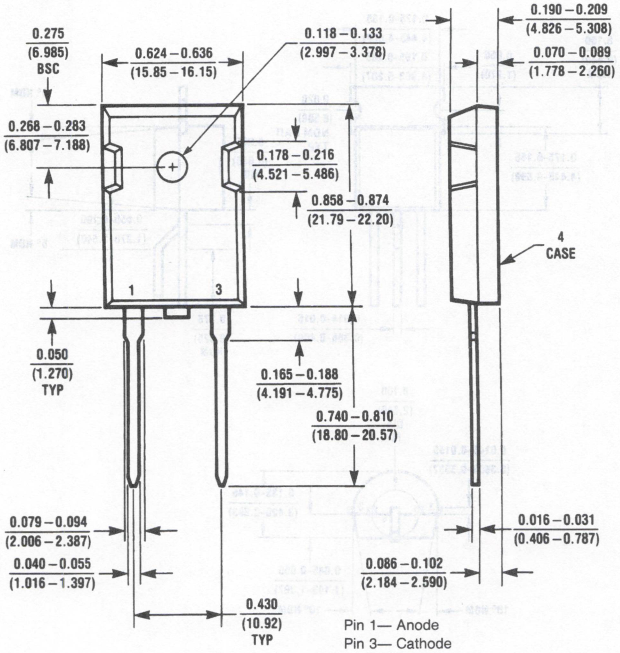
TO-237 (90, 91)
TO-5 Lead Form - 05 Option


0.175 – 0.185
(4.445 – 4.699)
0.300
(7.620)
NOM
0.025
(0.635)
MIN
0.050 – 0.100
(1.270 – 2.540)
0.475
(12.07)
NOM
0.375
(9.525)
NOM
0.015 – 0.019
(0.381 – 0.482)
TYP
0.095 – 0.105
(2.413 – 2.667)
R
0.135 – 0.145
(3.429 – 3.683)
2
1
3
0.045 – 0.055
(1.143 – 1.397)
0.045 – 0.055
(1.143 – 1.397)

TL/G/10336-47

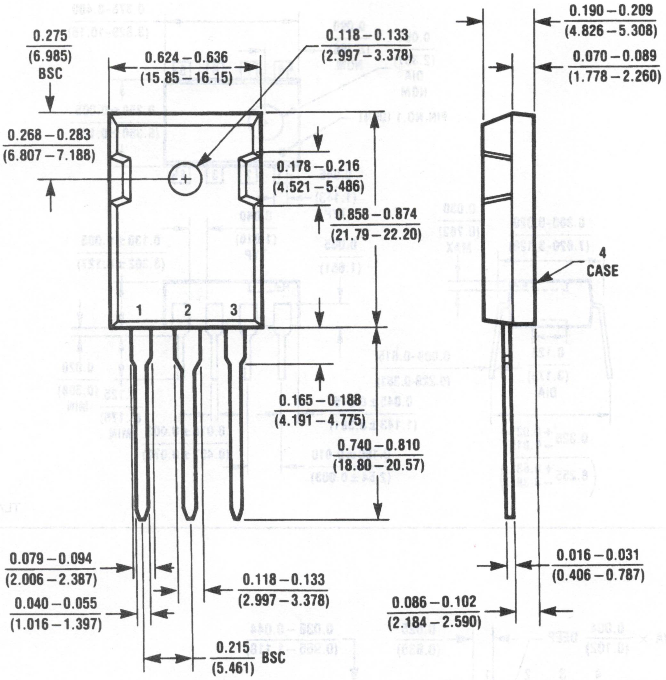
TO-247/DO-3P (44)
(Rectifier Package)

Pin	R (44)
1	A
2	Cut
3	C


0.275
(6.985)
BSC
0.624 – 0.636
(15.85 – 16.15)
0.118 – 0.133
(2.997 – 3.378)
0.190 – 0.209
(4.826 – 5.308)
0.070 – 0.089
(1.778 – 2.260)
0.268 – 0.283
(6.807 – 7.188)
0.178 – 0.216
(4.521 – 5.486)
0.858 – 0.874
(21.79 – 22.20)
4
CASE
1
3
0.050
(1.270)
TYP
0.165 – 0.188
(4.191 – 4.775)
0.740 – 0.810
(18.80 – 20.57)
0.079 – 0.094
(2.006 – 2.387)
0.016 – 0.031
(0.406 – 0.787)
0.040 – 0.055
(1.016 – 1.397)
0.086 – 0.102
(2.184 – 2.590)
0.430
(10.92)
TYP
Pin 1— Anode
Pin 3— Cathode

TL/G/10336-48

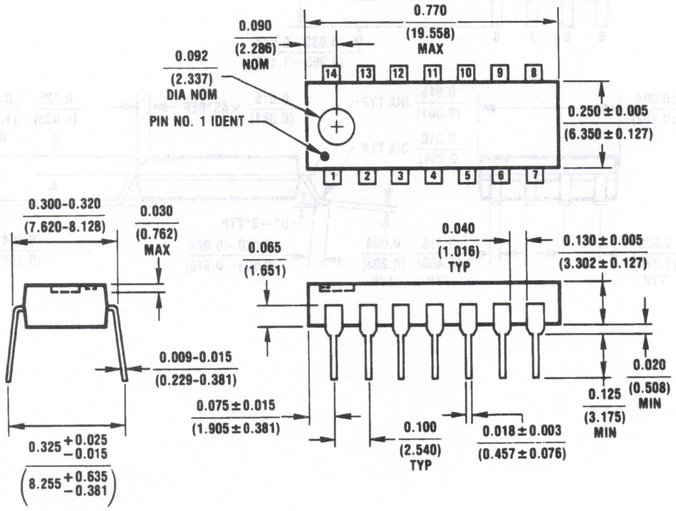
TO-247/TO-3P (40)


0.275
(6.985)
BSC
0.624 – 0.636
(15.85 – 16.15)
0.118 – 0.133
(2.997 – 3.378)
0.268 – 0.283
(6.807 – 7.188)
0.178 – 0.216
(4.521 – 5.486)
0.858 – 0.874
(21.79 – 22.20)
1
2
3
0.165 – 0.188
(4.191 – 4.775)
0.740 – 0.810
(18.80 – 20.57)
0.190 – 0.209
(4.826 – 5.308)
0.070 – 0.089
(1.778 – 2.260)
4
CASE
0.079 – 0.094
(2.006 – 2.387)
0.040 – 0.055
(1.016 – 1.397)
0.118 – 0.133
(2.997 – 3.378)
0.215
(5.461)
BSC
0.016 – 0.031
(0.406 – 0.787)
0.086 – 0.102
(2.184 – 2.590)

Pin	FET(40)	R(40)
1	G	See
2	D	Part
3	S	Nmbr.

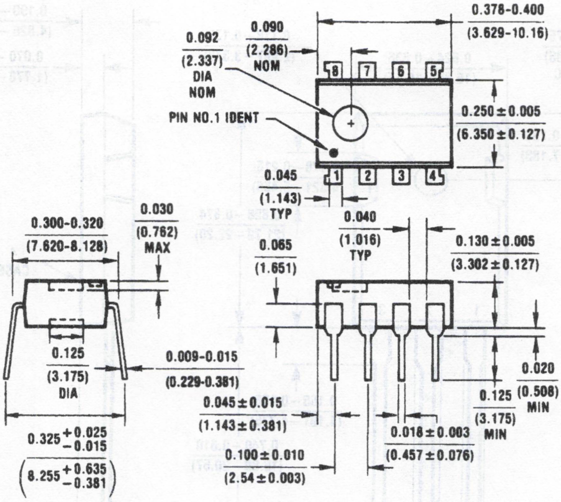
TL/G/10336-49

Molded Dual-In-Line Package (39) (Diode Arrays)


0.770
(19.558)
MAX
0.090
(2.286)
NOM
0.092
(2.337)
DIA NOM
PIN NO. 1 IDENT
14
13
12
11
10
9
8
1
2
3
4
5
6
7
0.250 ± 0.005
(6.350 ± 0.127)
0.300-0.320
(7.620-8.128)
0.030
(0.762)
MAX
0.065
(1.651)
0.040
(1.016)
TYP
0.130 ± 0.005
(3.302 ± 0.127)
0.009-0.015
(0.229-0.381)
0.020
(0.508)
MIN
0.125
(3.175)
MIN
0.075 ± 0.015
(1.905 ± 0.381)
0.100
(2.540)
TYP
0.018 ± 0.003
(0.457 ± 0.076)
0.325 +0.025 −0.015
(8.255 +0.635 −0.381)

TL/G/10336-50

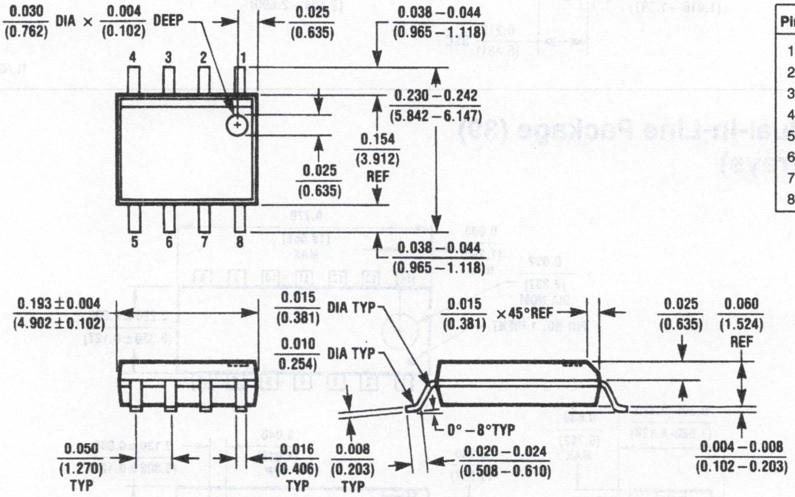
Molded Mini-DIP (60, 67)


0.378-0.400
(3.629-10.16)
0.090
(2.286)
NOM
0.092
(2.337)
DIA
NOM
PIN NO.1 IDENT
8
7
6
5
1
2
3
4
0.250 ± 0.005
(6.350 ± 0.127)
0.045
(1.143)
TYP
0.030
(0.762)
MAX
0.300-0.320
(7.620-8.128)
0.040
(1.016)
TYP
0.065
(1.651)
0.130 ± 0.005
(3.302 ± 0.127)
0.125
(3.175)
DIA
0.009-0.015
(0.229-0.381)
0.020
(0.508)
MIN
0.045 ± 0.015
(1.143 ± 0.381)
0.125
(3.175)
MIN
0.325 +0.025 −0.015
(8.255 +0.635 −0.381)
0.018 ± 0.003
(0.457 ± 0.076)
0.100 ± 0.010
(2.54 ± 0.003)

Pin	(60)	(67)
1	NC	S1
2	S1	D1
3	D1	NC
4	G1	G1
5	S2	S2
6	D2	D2
7	G2	NC
8	NC	G2

TL/G/10336-51

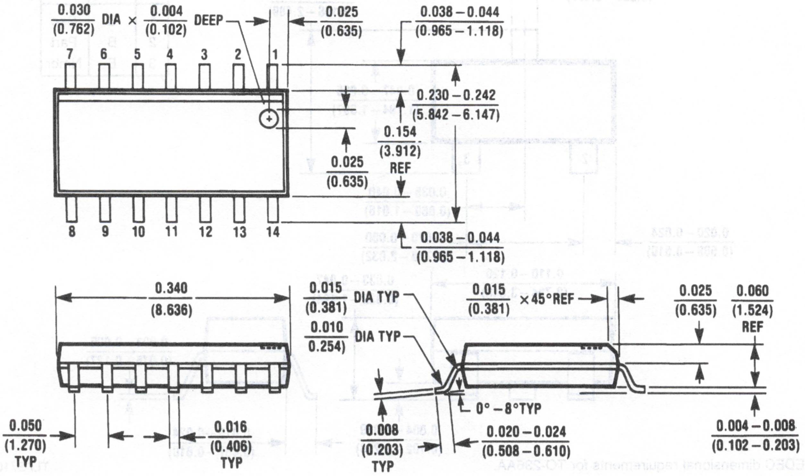
8-SOIC (S1)


0.030
(0.762)
DIA ×
0.004
(0.102)
DEEP
0.025
(0.635)
0.038 − 0.044
(0.965 − 1.118)
4
3
2
1
0.230 − 0.242
(5.842 − 6.147)
0.154
(3.912)
REF
0.025
(0.635)
5
6
7
8
0.038 − 0.044
(0.965 − 1.118)
0.193 ± 0.004
(4.902 ± 0.102)
0.015
(0.381)
DIA TYP
0.010
0.254)
DIA TYP
0.015
(0.381)
× 45° REF
0.025
(0.635)
0.060
(1.524)
REF
0° − 8° TYP
0.050
(1.270)
TYP
0.016
(0.406)
TYP
0.008
(0.203)
TYP
0.020 − 0.024
(0.508 − 0.610)
0.004 − 0.008
(0.102 − 0.203)

Pin	T(S1)	D(S1)
1	S1	See Part Number
2	D1	
3	NC	
4	G1	
5	S2	
6	D2	
7	NC	
8	G2	

TL/G/10336-52

14-SOIC (S2) (Diode Arrays)


0.030 (0.762) DIA × 0.004 (0.102) DEEP
0.025 (0.635)
0.038 – 0.044 (0.965 – 1.118)
7 6 5 4 3 2 1
0.230 – 0.242 (5.842 – 6.147)
0.154 (3.912) REF
0.025 (0.635)
8 9 10 11 12 13 14
0.038 – 0.044 (0.965 – 1.118)
0.340 (8.636)
0.015 (0.381) DIA TYP
0.010 (0.254) DIA TYP
0.015 (0.381) × 45°REF
0.025 (0.635)
0.060 (1.524) REF
0° – 8°TYP
0.050 (1.270) TYP
0.016 (0.406) TYP
0.008 (0.203) TYP
0.020 – 0.024 (0.508 – 0.610)
0.004 – 0.008 (0.102 – 0.203)

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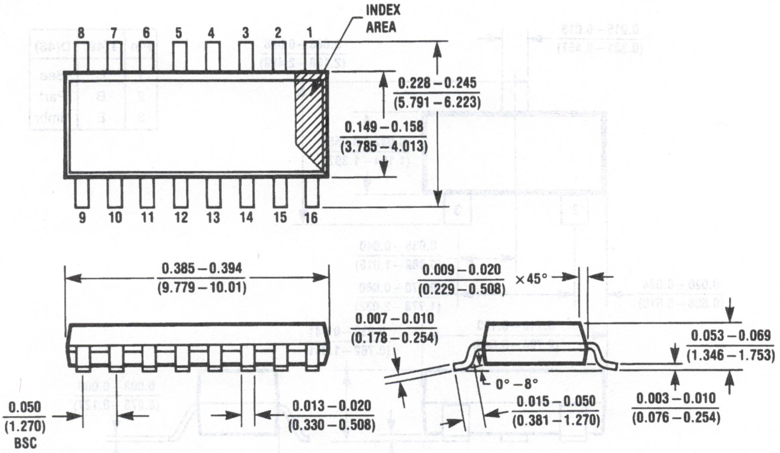
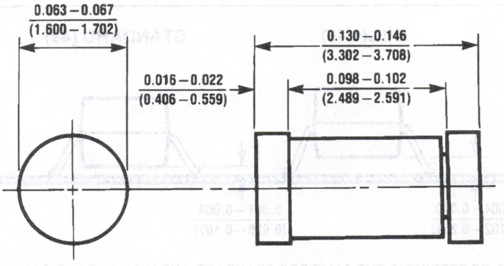
16-SOIC (S3)


INDEX AREA
8 7 6 5 4 3 2 1
0.228 – 0.245 (5.791 – 6.223)
0.149 – 0.158 (3.785 – 4.013)
9 10 11 12 13 14 15 16
0.385 – 0.394 (9.779 – 10.01)
0.009 – 0.020 (0.229 – 0.508) × 45°
0.007 – 0.010 (0.178 – 0.254)
0.053 – 0.069 (1.346 – 1.753)
0° – 8°
0.050 (1.270) BSC
0.013 – 0.020 (0.330 – 0.508)
0.015 – 0.050 (0.381 – 1.270)
0.003 – 0.010 (0.076 – 0.254)

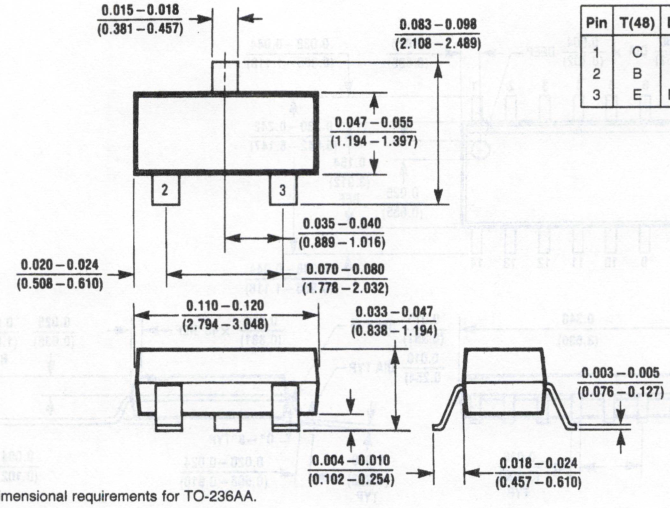
TL/G/10336-54

LL-34 (D3)


0.063 – 0.067 (1.600 – 1.702)
0.130 – 0.146 (3.302 – 3.708)
0.016 – 0.022 (0.406 – 0.559)
0.098 – 0.102 (2.489 – 2.591)

TL/G/10336-55

TO-236AA (48) (SOT-23)


0.015-0.018
(0.381-0.457)
0.083-0.098
(2.108-2.489)
0.047-0.055
(1.194-1.397)
2
3
0.035-0.040
(0.889-1.016)
0.020-0.024
(0.508-0.610)
0.070-0.080
(1.778-2.032)
0.110-0.120
(2.794-3.048)
0.033-0.047
(0.838-1.194)
0.003-0.005
(0.076-0.127)
0.004-0.010
(0.102-0.254)
0.018-0.024
(0.457-0.610)

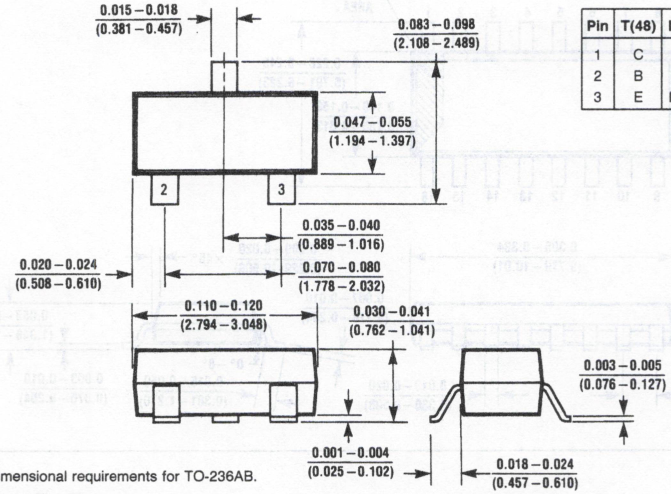
Pin	T(48)	D(48)
1	C	See
2	B	Part
3	E	Nmbr

Note 1: Meets all JEDEC dimensional requirements for TO-236AA.

Note 2: Controlling dimension: millimeters.

TL/G/10336-56

TO-236AB (49) (SOT-23)

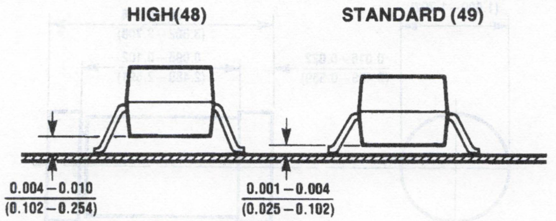

0.015-0.018
(0.381-0.457)
0.083-0.098
(2.108-2.489)
0.047-0.055
(1.194-1.397)
2
3
0.035-0.040
(0.889-1.016)
0.020-0.024
(0.508-0.610)
0.070-0.080
(1.778-2.032)
0.110-0.120
(2.794-3.048)
0.030-0.041
(0.762-1.041)
0.003-0.005
(0.076-0.127)
0.001-0.004
(0.025-0.102)
0.018-0.024
(0.457-0.610)

Pin	T(48)	D(48)
1	C	See
2	B	Part
3	E	Nmbr

Note 1: Meets all JEDEC dimensional requirements for TO-236AB.

Note 2: Controlling dimension: millimeters.

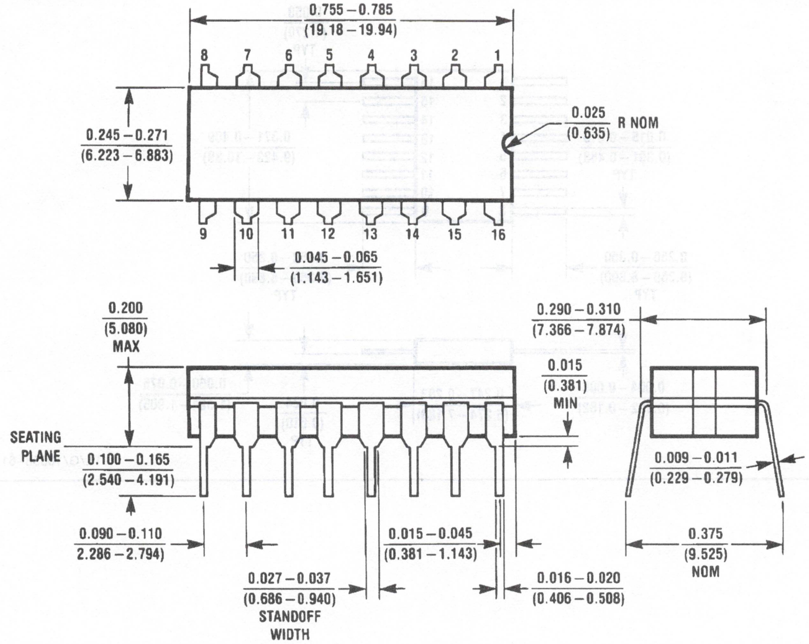
TL/G/10336-57


HIGH(48)
STANDARD (49)
0.004-0.010
(0.102-0.254)
0.001-0.004
(0.025-0.102)

TL/G/10336-58

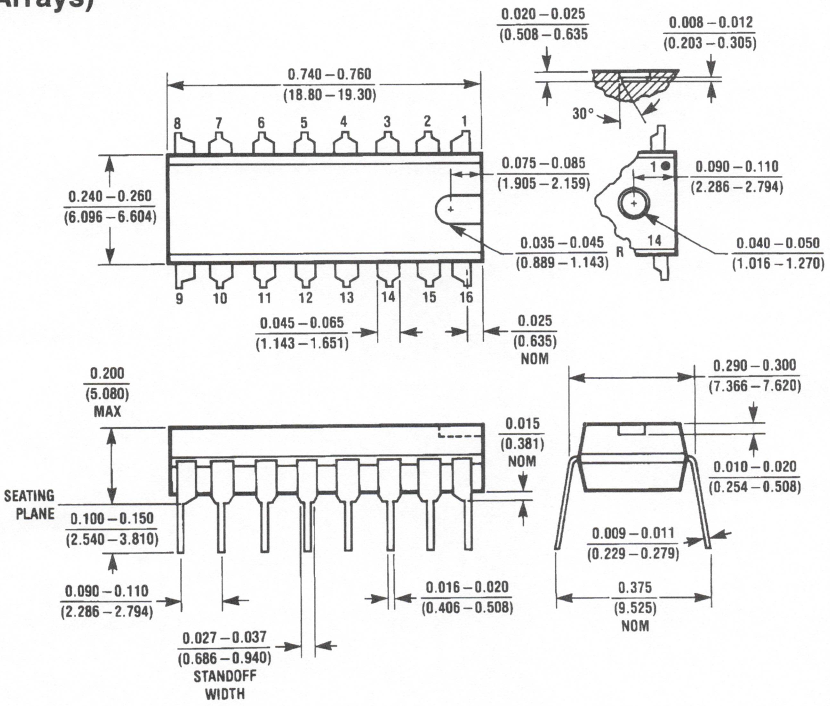
NOTE: FOOTPRINT IS THE SAME FOR STANDARD AND HIGH PROFILE PACKAGES.

16-Lead Ceramic (27) (Diode Arrays)


0.755 – 0.785
(19.18 – 19.94)
8 7 6 5 4 3 2 1
0.245 – 0.271
(6.223 – 6.883)
0.025
(0.635)
R NOM
9 10 11 12 13 14 15 16
0.045 – 0.065
(1.143 – 1.651)
0.200
(5.080)
MAX
0.290 – 0.310
(7.366 – 7.874)
0.015
(0.381)
MIN
SEATING PLANE
0.100 – 0.165
(2.540 – 4.191)
0.009 – 0.011
(0.229 – 0.279)
0.090 – 0.110
2.286 – 2.794)
0.015 – 0.045
(0.381 – 1.143)
0.375
(9.525)
NOM
0.027 – 0.037
(0.686 – 0.940)
STANDOFF
WIDTH
0.016 – 0.020
(0.406 – 0.508)

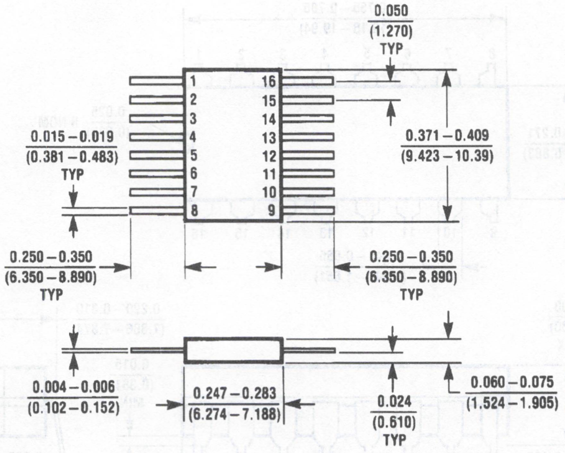
TL/G/10336-59

16-Lead Plastic (03) (Diode Arrays)


0.020 – 0.025
(0.508 – 0.635
0.008 – 0.012
(0.203 – 0.305)
0.740 – 0.760
(18.80 – 19.30)
30°
8 7 6 5 4 3 2 1
0.240 – 0.260
(6.096 – 6.604)
0.075 – 0.085
(1.905 – 2.159)
1
0.090 – 0.110
(2.286 – 2.794)
0.035 – 0.045
(0.889 – 1.143)
R
14
0.040 – 0.050
(1.016 – 1.270)
9 10 11 12 13 14 15 16
0.045 – 0.065
(1.143 – 1.651)
0.025
(0.635)
NOM
0.200
(5.080)
MAX
0.290 – 0.300
(7.366 – 7.620)
0.015
(0.381)
NOM
0.010 – 0.020
(0.254 – 0.508)
SEATING PLANE
0.100 – 0.150
(2.540 – 3.810)
0.009 – 0.011
(0.229 – 0.279)
0.090 – 0.110
(2.286 – 2.794)
0.016 – 0.020
(0.406 – 0.508)
0.375
(9.525)
NOM
0.027 – 0.037
(0.686 – 0.940)
STANDOFF
WIDTH

TL/G/10336-60

16-Lead Flat Pack (4L) (Diode Arrays)


0.050
(1.270)
TYP
1
2
3
4
5
6
7
8
16
15
14
13
12
11
10
9
0.015 – 0.019
(0.381 – 0.483)
TYP
0.371 – 0.409
(9.423 – 10.39)
0.250 – 0.350
(6.350 – 8.890)
TYP
0.250 – 0.350
(6.350 – 8.890)
TYP
0.004 – 0.006
(0.102 – 0.152)
0.247 – 0.283
(6.274 – 7.188)
0.024
(0.610)
TYP
0.060 – 0.075
(1.524 – 1.905)

TL/G/10336-61

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